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ABSTRACT

Part of a manufacturing cluster series which addresses itself to career awareness, orientation, exploration, and preparation, this guide and its accompanying student manual were written as a direct followup of the instructor's guide and student manual titled "Exploring Manufacturing Occupations." Four major sections are included. The first section provides the instructor with a brief outline for initiating a career preparation program in the overall area of manufacturing occupations. A brief overview of preparation in the specific areas of quality control and inspection are presented in the second section. The third section deals with a suggested method, or model, of development, preparation, and conduct of a program dealing with quality control and inspection. Twenty pages of individual items are provided which the instructor may use as a checklist to stimulate student interest and to reinforce the overall scope of inspection and quality control. Items are listed under the broader headings of What the Worker Does, What Licenses and Certificates are Required, Union Affiliation within Industry, Communication Responsibilities, Education and Training Levels, Subjects and Courses Needed, Specializations in Inspection and Testing, and Machines, Tools, Equipment, and Work Aids. The fourth and major section is divided into two subsections: General Background and Occupational Information, which includes eight units; and Occupational Preparation, which includes the five units of Blueprint Reading, Statistics in Quality Control, Mechanical Measurement, Electrical Measurement, and Chemical Measurement. Each unit presents objectives, teaching content, evaluation, and other information pertaining to the unit area. An 18-page bibliography of texts and audiovisual materials is appended. (SH)

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THE MANUFACTURING CLUSTER

OCCUPATIONAL PREPARATION—
INSPECTION AND
QUALITY CONTROL

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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INSTRUCTOR'S GUIDE

CE 010 399

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1975

This document is part of the Manufacturing Cluster Series
which addresses itself to career awareness, orientation, exploration and preparation.

The series includes student manuals and instructor guides for
use at the secondary level.

The list of titles in this series is as follows:

Exploring Manufacturing Occupations: Student's Manual

Exploring Manufacturing Occupations: Instructor's Guide

Occupational Preparation - Inspection and Quality
Control: Student's Manual

Occupational Preparation - Inspection and Quality
Control: Instructor's Guide

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FOREWORD

This Occupational Preparation in the Quality Control and Inspection Field is written as a direct follow-up of the Exploring Manufacturing: Instructors Guide. The Exploring Guide's purpose was to:

1. promote an understanding of manufacturing industry;
2. acquaint the students with structures of the many careers, occupations and jobs contained with manufacturing enterprise;
3. explore selected career fields by use of a typical program example; and
4. provide a generalized set of guidelines for further and related curriculum development in the exploration realm.

This Guide continues those four purposes into the preparation phase in the same manner. This is accomplished by utilizing a program example in the curriculum development guidelines.

As was the case in the exploration phase, some delimitation in the preparation for career fields was necessary. The concentration in quality control was chosen because it contains skills and knowledges that are broad; the comprehensive job classes examined have high relationship with all of the major sub-functions of manufacturing enterprise. This program guide will fit within the scope of purpose and present on-going secondary school programs in the academic, industrial and vocational curriculums.

The teaching/learning program team model contained in the exploration phase is suggested as a resource in the curriculum developed as a result of this Guide. The conduct of the program--as specific skills are developed becomes the focal point--encouraging use of prescribed resources.

The instructor is invited to review the Exploring Manufacturing Occupations: Student Manual and Instructor's Guide. This is covered in the first section with a suggested program outline of preparation.

The next section is a brief overview of preparation in the quality control and inspection career field.

The third section of this Guide deals with a suggested method or model of development, preparation and conduct of a program dealing with the careers of quality control and inspection. This method is in tune with the Student's Manual, therefore, it is important that the instructor recognize the importance of the six model elements presented in this section. They represent the objective function of decision making which is applicable to many skills besides quality control and inspection.

The largest section of this Guide deals with the generalized skills and knowledge contained within the quality control and inspection career field. These are task lists, inspection criteria, skills utilized, knowledge needed, labor/management operations, comprehensive lists of pertinent subjects, courses and typical machines, tools and equipment utilized in performing the sub-functions inherent in this career field.

By approaching the preparation phase in a broad sense, it is sincerely hoped that interested students will see the importance of their skills and knowledge in quality control and inspection across the industrial job market.

John E. Radvany
Deputy Assistant Commissioner
New Jersey Department of Education
Division of Vocational Education

ACKNOWLEDGEMENTS

As with any project encompassing such a diversified field as Manufacturing Enterprise, this is the result of the efforts of countless persons who have supplied the knowledge, and the facts upon which it rests. Philosophy, rationale, information, critique, testing and change have been reviewed by special personnel who worked on, or supplied information to this project.

To all the many advisory personnel and committee members, sincere thanks are due. It is impossible to list them all and delineate their contribution.

The Manufacturing Cluster Series of which this is a part represents an effort in curriculum development by the United States Office of Education, the New Jersey Department of Education and Fairleigh Dickinson University.

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OUTLINE FOR INSTRUCTOR REVIEW FOR INITIATING A CAREER PREPARATION PROGRAM IN MANUFACTURING OCCUPATIONS

INTRODUCTION

The instructor is referred to the Exploring Manufacturing Occupations: Instructor's Guide.

A review of the comprehensive exploration of career fields and jobs in the manufacturing cluster will assist the instructor in relating to the students the specifics of career exploration and career preparation in the inspection and quality control field.

The following outline is intended to help the instructor maintain an overview of the career fields and occupational opportunities available to the students for future employment in the manufacturing industry.

It may be necessary for the instructor to refer to the Exploring Manufacturing Occupations: Student Manual and Instructor's Guide when detailed information is needed for instructional support in the use of this Guide.

THE MANUFACTURING CAREER PREPARATION PROGRAM OUTLINE

GENERALIZED PROGRAM TEAM MODEL

The model is recommended as a necessary support consortia for assistance in implementing and developing the exploration/preparation activities in the school.

MAJOR PRE-OPERATIONAL FACTORS

It is suggested that the detail given in the exploration Guide include the following facts for consideration during the planning, design and implementation phase of the school program.

1. Time: It is a dimension that affects program, facilities, staff and students.
2. Facilities: This can be a constraint or an asset if it involves cooperation with industry.

3. Materials: This is considered in terms of availability from the industrial community or the need to purchase for in-school use.
4. Finances: Costs must be a major factor to be considered in developing the curriculum.
5. Participant Roles: This refers to administrators, learning specialists, enrolled students and support personnel from industry and the community with each providing inputs and outputs for the success of the program.

GENERALIZED CURRICULUM MODEL

The Generalized Curriculum Model reviews the comprehensiveness of activities involved in the broad occupational fields in the manufacturing industry.

It also permits a more specific assessment of job families and jobs within the manufacturing industry.

The Generalized Curriculum Development Model is depicted in Figure 3, page 27, in Exploring Manufacturing Occupations: Instructor's Guide. The instructor may wish to refer to the diagram shown in Figure 3 as well as review the narrative which details the operations of the systems oriented model.

THE MANUFACTURING ENTERPRISE

Briefly, the history of manufacturing in the United States, given in the Exploring Manufacturing Occupations: Instructor's Guide provides an overview of the industry.

Characteristically, manufacturing as an industry is given consideration in terms of: facilities, finance, machine tools, the work force and time.

In the area of production and productivity, the Guide addresses itself to the factors that determine productivity, an important consideration in the manufacturing enterprise.

The factors of productivity discussed include:

1. Technological improvements
2. Management
3. Finances
4. Labor force
5. Government and environmental controls

CHANGES AND PROGRESS

A brief discussion is presented which relates to industrial and technological changes since the end of World War II.

MANUFACTURING AND SOCIAL PROGRESS

The Guide covers social progress with its affect on education, response of school systems with program changes and specifics in the area of manufacturing as an industry that has an effect on society.

THE STRUCTURE OF MANUFACTURING

The Structure of Manufacturing as shown in Figure 2, page 16, in Exploring Manufacturing Occupations: Instructor's Guide is repeated here. The figure, with its narrative covers functions, processes and products of manufacturing and provides a basis for in-depth occupational preparation in the inspection and quality control field.

OCCUPATIONAL PREPARATION IN THE QUALITY CONTROL AND INSPECTION FIELD

INTRODUCTION

Students who have selected preparation in this career, occupation or job field should have had some prerequisite instruction in the manufacturing enterprise area. Typical pre-preparation would include:

1. Instruction and experience gained in the Exploring Manufacturing Occupations: Student's Manual; and/or,
2. Instruction and experience gained in The World of Manufacturing program; McKnight and McKnight, Bloomington, Illinois, 1971; and/or,
3. Instruction and experience gained in an industrial arts or vocational program or selected skills acquisition courses in trades or general laboratory; general physics and chemistry; economics and general math.

Specific prerequisite skills and knowledge is not needed in any of the above areas in order to participate in the quality control and inspection program but student interest in these areas would be a great aid.

For the instructor, the preceding section along with this one deals in preparation by reviewing the exploring occupations, Student's Manual and Instructor's Guide and the general preparation in the quality control and inspection career field.

The instructor is then offered a model dealing with the development, preparation and the conducting of a program of instruction in quality control and inspection.

It is important to remember that within the preparation phase the student is exploring while being taught. The balance of this Guide attempts to stimulate while preparing. Students may still be exploring, i.e., changing his/her direction and/or focus due to awareness of other and more interesting career areas in which they would like to explore and/or prepare. This particular course of instruction has been designed expressly for this interaction by the student. The field of inspection is central to the course, but the quality control concept is the vehicle of instruction. After exploring and trying the inspection field, students may opt for the higher technician or engineering echelons of the career field. This may require the students to rearrange their programs

with at least a balance of academic and vocational subjects, if not a return to or emphasis on academic subjects, to include courses for preparation in more demanding job requirements.

Generally, along with the career education intent, this Guide attempts to promote student interest via awareness to the exploration and preparation phases of instruction so that they may better realize their individual potential.

GUIDELINES FOR DEVELOPMENT AND CONDUCT OF A TYPICAL PREPARATION PROGRAM IN THE QUALITY CONTROL AND INSPECTION CAREER FIELD

COMPREHENSIVE SUBJECT MATTER

This guideline has been developed to use the factors and elements of the generalized formats and models contained in the student manual. These total efforts and resources are assembled to help the teacher meet the goals of career education preparation programs as follows:¹

1. Intensive training in a selected occupational family or job in preparation for job-entry and/or continuing formal education;
2. Improvement of general student performance by relating studies to the chosen area of work;
3. Providing occupational guidance and information congruent with student purposes; and,
4. Insuring that students meet job-entry and continuing education prerequisites.

These objectives/goals are both easy and difficult to attain. An interpretation is needed about "intensive," "job-entry requisites" and "improvement." What is generally thought to be acceptable in a definition may not be approvable in the real environment, because there are variables--and, basically uncontrolled ones.

Emphasizing one area of preparation for careers can cause bias. Too little time, alone, can be a factor as well as too much concentration on one area. If it is very much desired to learn blueprint reading to meet job-entry requirements, this can be accomplished in 40 hours of instruction. If it is desired to teach blueprint reading for purposes of understanding how a blueprint is made, what it means, and how it is utilized by various manufacturing sub-functions, this may take considerably longer.

The consortia of school staff, students, industry, labor, community and resource personnel will have to--for any given school system--help determine what is meant by the overall goals and objectives.

¹Department of Health, Education and Welfare; Career Education;
Office of Education pamphlet; Washington, D.C. 1971.

This suggested typical program is presented so that the information covers the four major objectives of career education preparation. This is not meant to prevent the program from becoming as intensive as is felt necessary by the instructional system. The topics are broad in nature but they also contain many interpretive articulation points both for convergent as well as divergent purposes.

As in the exploration phase course of study in the manufacturing cluster, the field of quality control is used as the learning vehicle. This field choice is ideally suited to gain maximum learning and linkage to nearly all other manufacturing sub-functions. Exploration and preparation phases are not marked by a line cleavage; exploration and awareness continue through preparation. Utilization of an overview and related studies is an excellent way to generate information, be it for guidance, actual work or for future consideration by the student.

In this way, all four career education preparation objectives are addressed and interrelated. This will provide one means for using objectives 2 and 3 to be considered in the integration of objectives 1 and 4 with the instruction as a major determination in reaching the objectives, as well as in this particular program example, the instructor will utilize the resources of his program-team.

DEFINITION OF QUALITY CONTROL AND INSPECTION

It is necessary to define the terms quality control and inspection as they are encountered in modern and real work situations. Quality control can be thought of as an abstract; i.e., every function of life can be observed to have a quality and a means of control. Because we have senses we inspect naturally, all the time.

In the quality control field, quality control is defined as:

- narrow: The necessary activities which must be performed in order to meet the company's quality objective.
- broad: The total of all activities which should be performed in order to meet the company's quality objective.

Using these definitions as a baseline, quality control becomes functional. This develops the concept of quality-control as being defined in terms of a process. Inspection, proofing, auditing, examination, and testing are major descriptors and, sometimes, are synonyms of quality control.

Quality control can be related and further defined by its other characteristics, namely: tools and equipment; the quality control organization; and/or, the quality control system.

Usually, quality control is concerned with:

1. manufacturing economics
2. manufacturing capabilities
3. training and education within its section
4. statistical studies
5. statistical design; sampling plans, testing plans
6. statistical analysis
7. product usage; complaints/returns, acceptability/re-order
8. reporting on all items above.

Quality control must not be confused with manufacturing quality. Quality control is concerned with enhancing and/or maintaining product quality. While quality control cannot put the "qualities" into the product, it can determine whether they are there or not.

INSPECTION

Simply put, inspection is an action. It is the primary action of quality control. Normally inspection is concerned with:

1. Inspection of incoming materials
2. Inspection of products as they are in-process of manufacture
3. Inspection of finished/final products, including testing
4. Inspection and verification of inspection tools, equipments and methodology
5. Providing data on reclamation of scrap for salvage purposes.

QUALITY CONTROL AND INSPECTION, A FUNCTIONAL MODEL

Quality control and inspection is functional, scientific and programmatic. It operates within the model structure of:

1. Specification Interpretation (quality characteristics)
2. Product Qualities Measurement
3. Comparison of Specification Qualities Limits and Measurement of Actual Product Qualities

4. Determination of Conformance
5. Recording of the Data/Information
6. Making a Disposition (accept, recycle, reject)

All quality control efforts are addressed to these six model elements. Inspection is the action by which items one through four are accomplished.

As the students enter and pursue this course of instruction, they can use the same model to determine whether or not:

1. they want to continue--at any point in time; or
2. whether they meet requirements of the occupational or job level they are interested in.

The model, elements one through six, is a decision-making model. From this model, a more specific definition of quality control can be attempted, once the six elements are analyzed for meaning. The degree of meaning is what determines the exact definition of quality control. For example, consider the slogan of "X" Corporation--manufacturers of television sets; "The quality goes in before the name goes on." Using the model elements: What does the statement mean, exactly? What does the statement imply? The history of product performance may show that "X" Corporation makes good equipment compared to others. Yet, they cannot have quality control, nor tell people they have, simply by saying so. Procedures usually followed are:

First, a specification stating the exact qualities to be measured must be obtained.

Second, tooling, equipment and methodology must be available which is capable of measuring those "qualities."

Third, some way of comparing the two must be available, by sight, feel, smell, arithmetic, algebra or statistics.

Fourth, a judgment must be made whether this product has those qualities based on the above.

Fifth, the data/information must be recorded for legal, operating and decision-making purposes.

Sixth, the disposition must be made.

Quality control and inspection functions must have the first three items or it cannot start to operate properly. The last three items are important to quality control and inspection philosophy, concepts, rules, regulations, procedures and personnel.

The model is an operational model of quality control and inspection in general terms. It is both an objective and subjective model. Because quality control and inspection procedures are based in science, the responsibility level is much more objective than subjective. In the ideal sense, measurement and decisions are made by comparison to a standard specification as "go" or "no-go." The model may be used for purposes of examining other functions, such as management which leads to more subjective considerations. This will be the case, also, when the instructor and/or student uses the model elements to maintain their own personal quality control.

SKILLS AND KNOWLEDGE IN THE QUALITY CONTROL AND INSPECTION CAREER FIELD

While the following can be used in the development of an in-depth curriculum within the quality control field, it can also be useful in helping to define a career profile in a technical education program.

The extensive list of related work under generalized skills is applicable to the quality control and inspection career field and should be used only as a stimulation to develop the student's interest.

GENERAL BACKGROUND AND OCCUPATIONAL INFORMATION

Before initiating the course of instruction, certain occupational information should be considered. Although it is assumed that guidance and counseling functions have been available to this program during the exploration and beginning preparation phases, it would be well to determine if guidance and information needs must be continued and/or reinforced for the duration of the course.

Somewhere near the end of the previous exploration phase of instruction the students have acquired knowledge about themselves and their chosen occupation or career field. They have assessed and evaluated themselves and been assessed and evaluated by others in the typical areas of:

1. self-understanding
2. occupational understanding

Usually the areas evaluated are:

1. past performance
2. previous experiences
3. selected study-work programs
4. awareness, orientation and exploration study programs in occupations, jobs or careers.

The persons who have assessed and evaluated the students have been and are: friends, parents, school system personnel, workers, and, possibly employers.

As they enter into preparation for either job-entry or further studies and later into job-entry or further instruction, more areas of evaluation come into play. Typically, these are:

1. selection of a school or university
2. selection of a program of study
3. entry into work-study programs
4. entry into apprenticeship programs
5. necessary geographical mobility
6. requisite certification or licenses
7. union or professional organizations.

These must all be considered, and again, they will be assessed and evaluated by the student-worker and other persons. The quality control of these areas should be understood at this point of program inception. External resource personnel and guidance counselors--from the program-team-model should meet to discuss these items and supply additional information and facts helpful to the students.

Students who are going into jobs immediately should be given a presentation of typical inspection and inspector-trainee job duties, requisites, general educational development levels, specific vocational preparation. Attitude, physical and environmental profiles should also be discussed, possibly with any State Training and Employment Service (State Department of Labor) which will provide excellent service in pursuit of the above job-entry needs. The instructor is referred to the DICTIONARY OF OCCUPATIONAL TITLES, Volumes I and II for these purposes, as well as to the school district counseling and guidance department staff.

Students should have related information that will assist them in exploring, in a limited way, during this preparation phase. As they obtain new, different or update information in these categories, their perspectives may change. This will affect motivation and direction. Major points to be considered during the preparation phase are typically, factors which help determine direction and motivation and which help explain the occupation or job. They are:

hours of work (shift/straight night/day)	vacation
sick leave (how accrued and total)	parking
other transportation	cafeteria privileges
profit sharing plans	training and education
hospitalization benefits (major	programs
medical/dental)	retirement plan
seniority	military leave
bonuses	merit review (factors
unemployment benefits	and schedule)
tools, uniforms, equipment	licenses (paid or not)
service/suggestion awards	credit union
discount on products	athletic program

These factors fit into the industrial and labor resources personnel domain of knowledge more than a typical instructor's experience. Yet, some of these factors should be discussed in the class. Also, these factors become convenient vehicles for coordinating this career-oriented program into on-going academic and vocational programs. Seek assistance in this area from personnel managers of local business establishments.

The students should have the above categories of information reviewed with them upon their entry into this program. During the program these instructional areas will be repeated as they relate to preparation activities.

The following pages may be utilized as a checklist by the instructor to stimulate student interest and to reinforce the instructor's presentation reference the overall scope of inspection and quality control in areas of: testing and related work under generalized skills and knowledge includes:

1. what the worker does
2. what licenses and certificates are required
3. union affiliation within industry
4. communication responsibilities
5. education and training levels
6. subjects and courses needed
7. specializations in inspection and testing
8. machines, tools, equipment and work aids

INSPECTION, TESTING, AND RELATED WORK

Generalized Skills and Knowledge

WHAT THE WORKER DOES

Supervises, and coordinates activities, of workers engaged in inspection, testing, and quality assurance of materials and products.....()

Plans and determines:

- Manpower requirements.....()
- Worker schedules.....()
- Inspection and testing procedures.....()
- Training requirements.....()
- Product inspection and testing requirements.....()

Prepares work schedules.....()

Assigns workers to duties.....()

Gives workers directions for performing duties.....()

Interprets inspection and testing orders, product, specifications, drawings, and technical data.....()

Trains workers in:

- Inspection and testing duties.....()
- Operation of inspection and testing equipment.....()
- Safety practices and regulations.....()

Advises workers on methods and procedures for solving testing problems.....()

Coordinates quality assurance activities with production activities.....()

Enforces compliance with established work procedures, regulations, and safety rules.....()

Recommends promotions, demotions, discharges, and disciplinary actions.....()

Requisitions inspection and testing materials, tools, and equipment.....()

Keeps inspection and testing records.....()

Evaluates workers and prepares performance reports.....()

Perpares reports on quality assurance activities.....()

Performs periodic checks on products and materials.....()

Other (Specify).....()

Inspects, or examines materials, products, or product parts for:

- Quality.....()
- Workmanship.....()
- Coating imperfections.....()
- Surface defects.....()
- Uniformity of color.....()

WHAT THE WORKER DOES (Continued)

Processing defects.....()
Manufacturing defects.....()
Assembly defects.....()
Faulty installation.....()
Discoloration.....()
Damage.....()
Missing parts.....()
Identifying data.....()
Ease and freedom of movement.....()
Conformance with quality control standards, assembly
specifications, regulatory agency laws, directives,
or codes.....()
Completeness and accuracy of assembly.....()
Loose fitting and connections.....()
Presence of foreign materials.....()
Fit of interrelated parts.....()
Corrosion of materials.....()
Texture and consistency.....()
Grading purposes.....()
Wear of parts and need of replacement.....()
Vibration stresses.....()
Crystallization.....()
Drying quality.....()
Deterioration.....()
Blueprint specifications.....()
Weaving defects.....()
Concentricity.....()
Other (Specify).....()

Measures material parts or products for specified:

Alignment of parts.....()
Width.....()
Length.....()
Thickness.....()
Flatness.....()
Tolerances.....()
Shape and contour.....()
Volume.....()
Angular dimensions.....()
Radii.....()
Coating thickness.....()
Dioptric power.....()
Height.....()
Lens focal distance.....()
Clearances between moving parts.....()
Electrical characteristics.....()
Other (Specify).....()

WHAT THE WORKER DOES (Continued)

Tests materials, parts of products for:

Establishing quality control standards.....	()
Chemical properties.....	()
Acidity.....	()
Alkalinity.....	()
Absorption qualities.....	()
Solubility.....	()
Sediment.....	()
Turbidity.....	()
Viscosity.....	()
Specific gravity.....	()
Dielectric strength.....	()
Melting point.....	()
Hardness.....	()
Ductility.....	()
Boiling point.....	()
Compression characteristics.....	()
Vapor point.....	()
Malleability.....	()
Condensation point.....	()
Flash point.....	()
Aniline point.....	()
Freezing point.....	()
Porosity.....	()
Salinity.....	()
Permeability.....	()
Tensile strength.....	()
Elongation capabilities.....	()
Heat resistance.....	()
Alcohol content.....	()
Fade resistance.....	()
Density of color.....	()
Light values.....	()
Sugar content.....	()
Insulation efficiency.....	()
Adhesive qualities.....	()
Load test capabilities.....	()
Mechanical characteristics.....	()
Waterproofing qualities.....	()
Washability.....	()
Electrical.....	()
Polarity.....	()
Voltage.....	()
Amperage.....	()
Inductance.....	()
Shorts.....	()
Grounds.....	()

WHAT THE WORKER DOES (Continued)

Capacitance.....()
Circuit continuity.....()
Specified horsepower.....()
Physical properties.....()
Other (Specify).....()

Sorts materials or products according to:

Quality.....()
Style.....()
Weight.....()
Size.....()
Width.....()
Grade.....()
Color.....()
Nature of defects.....()
Shade of color.....()
Type.....()
Shape.....()
Surface blemishes.....()
Finish.....()
Other (Specify).....()

Studies blueprints, schematics, and circuit diagrams.....()
Reviews product specifications.....()
Reviews type and extent of test specified.....()
Turns dials on test equipment for conducting specified test..()
Positions and secures product or part in test fixture or
equipment.....()
Connects product or part to test equipment.....()
Opens valves and activates test equipment.....()
Tests product or part under simulated operational conditions.()
Reads gages, indicators, and meters on test equipment.....()
Refers to charts or tables for specified test readings.....()
Compares readings to ascertain discrepancies.....()
Analyzes test results.....()
Diagnoses cause of malfunction or discrepancies.....()
Prepares rejection slips, repair orders, or salvage orders...()
Attaches slips or orders to rejected products or parts.....()
Notifies supervisory personnel of defects found and
probable causes.....()
Notifies workers of corrections required to eliminate
defects.....()
Routes rejected articles, parts, or products for rework
or salvage.....()
Records number and type of defects on inspection record.....()
Compiles testing data for quality control purposes.....()
Conducts acceptance or performance tests.....()

WHAT THE WORKER DOES (Continued)

Reads dials and gages to evaluate performance.....()
Disassembles, replaces or repairs defective parts and
reassembles product.....()
Adjusts parts.....()
Moves parts for insuring ease and freedom of movement.....()
Starts pumps for testing pressure vessels.....()
Brushes soap solution over pressure vessels and
connections to locate leaks.....()
Holds flame next to product or connections to detect leaks... ()
Marks defects or defective areas on materials or products....()
Regrades products according to quality and type of defects...()
Marks or stamps inspection approval on products.....()
Stacks or places rejects in container.....()
Cuts sample of material from product.....()
Cuts excess material from product.....()
Prepares sample of material or product for testing.....()
Weighs material or product.....()
Moves parts to insure functional performance.....()
Compares operational performance with contract
specifications.....()
Approves work in compliance with building codes.....()
Orders rework of installations having variances from codes...()
Other (Specify).....()

LICENSURE, CERTIFICATES NEEDED

Federal.....()
State.....()
County.....()
City.....()
Other (Specify).....()

UNION AFFILIATION WITHIN INDUSTRY

Allied Industrial Workers of America.....()
Amalgamated Clothing Workers of America.....()
Association of Western Pulp and Paper Workers.....()
Bakers Union.....()
Bakery and Confectionery Workers, International Union
of America.....()
International Brotherhood of Boilermakers, Iron Ship-
builders, Blacksmiths, Forgers and Helpers.....()
Tile and Marble Helpers and Shopmans Local.....()
United Brick and Clay Workers of America.....()
International Brotherhood of Electrical Workers.....()
Electrical Workers Manufacturing Union.....()
United Furniture Workers of America.....()
Glass Workers and Glaziers Union.....()

UNION AFFILIATION WITHIN INDUSTRY (Continued)

Handbag, Luggage, and Leather Workers Union.....()
 Industrial Union of Marine and Shipbuilding Workers of
 America.....()
 International Brotherhood of Operative Potters.....()
 International Brotherhood of Pulp, Sulphite and Paper
 Mill Workers.....()
 International Association of Machinists and Aerospace
 Workers.....()
 International Ladies' Garment Workers Union.....()
 International Molders' and Allied Workers' Union.....()
 International Union of Electrical, Radio and Machine
 Workers.....()
 International Union of Toys and Doll Workers.....()
 Iron Workers, Ornamental and Architectural Union.....()
 International Jewelry Workers Union.....()
 Metal Polishers, Budders, Platers and Helpers
 International Union.....()
 Pattern Makers League of North America.....()
 Sheet Metal Workers' International Association.....()
 United Rubber Workers of America.....()
 United Steelworkers of America.....()
 United Textile Workers of America.....()
 Upholsterers International Union of North America.....()
 Watchmakers Union.....()
 Company Union.....()
 Other (Specify).....()

COMMUNICATION RESPONSIBILITIES

Management.....()
 Other supervisors.....()
 Quality control personnel.....()
 Laboratory personnel.....()
 Workers.....()
 Federal agencies.....()
 State agencies.....()
 Other (Specify).....()

EDUCATION AND TRAINING LEVELS

Elementary.....()
 High School.....()
 Junior College.....()
 College.....()
 Technical Training.....()
 Vocational Training.....()
 On-The-Job Training.....()

EDUCATION AND TRAINING LEVELS (Continued)

Military Training.....()
Apprenticeship Training.....()
Other (Specify).....()

SUBJECTS AND COURSES NEEDED

Algebra.....()
Geometry.....()
Shop Mathematics.....()
Applied Science.....()
Properties of Metals.....()
Properties of Materials.....()
Materials of Industry.....()
Use and Care of Tools.....()
Use and Care of Measuring Devices.....()
Use and Care of Testing Equipment.....()
Use and Care of Laboratory Equipment.....()
Elements of Basic Metallurgy.....()
Applied Chemistry.....()
Human Behavior of Employees.....()
Elements of Leadership.....()
Foremanship and Supervision.....()
Mechanical Drawing.....()
 Orthographic Projection.....()
 Sectional Views.....()
 Auxiliary Views.....()
 Isometric Projection.....()
 Lettering.....()
Blueprint Reading.....()
Magnetism and Electrical Energy.....()
Science Matter and Measurement.....()
Other (Specify).....()

Quality Control Principles and Practices.....()
Procurement Quality Control.....()
 Procurement Principles and Techniques.....()
 Inspection.....()
 Planning.....()
 Control.....()
 Performance.....()
 Lot Control.....()
 Non-Conforming Supplies.....()
 Corrective Action.....()
Quality Control Theory and Application.....()
 Fundamentals of Statistical Analysis.....()
 Case Problem Solving Applications.....()

SUBJECTS AND COURSES NEEDED (Continued)

Quality Control Management Concepts.....	()
Quality and Reliability Assurance.....	()
Organization and Objectives.....	()
Documentation.....	()
Planning and Costs.....	()
Introduction to Nondestructive Tests.....	()
Tools and Equipment.....	()
Nondestructive Testing Techniques.....	()
Liquid Penetrant Tests.....	()
Filtered and Magnetic Particle Tests.....	()
Introductory Radiation and X-Ray Testing.....	()
Ultrasonic and Eddy Current Tests.....	()
Introduction to Industrial Radiography.....	()
Functions of Radiography.....	()
Sources of Radiation.....	()
Radiographic Processes and Safety.....	()
Reliability and Maintainability Assurance.....	()
Concepts and Definitions.....	()
Useful Life of Components.....	()
Wearout Failures.....	()
Reliability Systems.....	()
Design Considerations.....	()
Measurements.....	()
Limits.....	()
Tests.....	()
Human Factors.....	()
Processing Quality Control.....	()
Electronic Quality Control.....	()
Introduction to Mechanical Metrology.....	()
Economics of Mechanical Measurements.....	()
Instrument Accuracies.....	()
Tolerances.....	()
Linear Measurements.....	()
Angular Measurements.....	()
Hardness Measurements.....	()
Temperature Measurements.....	()
Humidity Measurements.....	()
Density Measurements.....	()
Viscosity Measurements.....	()
Basic Measuring Instruments and Calibration.....	()
Introduction to Electrical-Electronic Metrology.....	()
Economics of Electrical Measurements.....	()
Instrument accuracies.....	()
Tolerances.....	()
Resistance Measurement.....	()
Voltage Measurement.....	()
Current Measurement.....	()

SUBJECTS AND COURSES NEEDED (Continued)

Capacitance Measurement.....	()
Inductance Measurement.....	()
Temperature Measurement.....	()
Humidity Measurement.....	()
Radiation Measurement.....	()
Light Measurement.....	()
Magnetic Measurement.....	()
Basic Measuring Instruments and Calibration.....	()
Introduction to Ultrasonic Testing.....	()
Basic System.....	()
Characteristics of Ultrasonic Wave Propagation.....	()
Transmissions.....	()
Reflection.....	()
Attenuation.....	()
Instruments.....	()
Interpretations.....	()
Applications.....	()
Magnetic Particle Testing.....	()
Penetrant Testing.....	()
Eddy Current Testing.....	()
Hardness Testing.....	()
Specifications and Standards.....	()
Instrument Calibration.....	()
Quality Control Specifications.....	()
Government Specifications.....	()
Regulatory Agency Specifications.....	()
Quality Control Planning.....	()
Procedures.....	()
Policies.....	()
Systems.....	()
Quality Control Documentation.....	()
Document Preparation.....	()
Document Distribution.....	()
Document Control.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING

Mining:

Metallic ores.....	()
Nonferrous ores.....	()
Precious metals.....	()
Ferroalloys.....	()
Coal.....	()
Petroleum.....	()
Natural gas.....	()
Stone.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Sand and gravel.....	()
Nonmetallic minerals.....	()
Chemical minerals.....	()
Construction:	
Highways and streets.....	()
Heavy construction structures.....	()
Plumbing installations.....	()
Heating installations.....	()
Air conditioning installations.....	()
Electrical work installations.....	()
Masonry and set stone installations.....	()
Carpentry work installations.....	()
Roofing installations.....	()
Sheet metal installations.....	()
Concrete work installations.....	()
Structural steel installations.....	()
Elevator installations.....	()
Ordnance:	
Large ordnance.....	()
Small arms.....	()
Large ordnance ammunition.....	()
Small arms ammunition.....	()
Sighting and fire control equipment.....	()
Food:	
Meats and meat products.....	()
Poultry.....	()
Dairy.....	()
Canned and preserved fruits.....	()
Canned and cured fish and sea foods.....	()
Dried and dehydrated fruits and vegetables.....	()
Pickled fruits and vegetables.....	()
Fresh or frozen foods.....	()
Grain mill.....	()
Bakery.....	()
Sugar.....	()
Confectionery.....	()
Beverages.....	()
Oils and shortenings.....	()
Tobacco.....	()
Textile mill:	
Woven fabrics.....	()
Knitted fabrics.....	()
Dyed and finished fabrics.....	()
Floor coverings.....	()
Yarn and thread.....	()
Felt goods.....	()
Lace goods.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Paddings and upholstery fillings.....	()
Artificial leather and coated fabrics.....	()
Tire cord and fabric.....	()
Cordage and twine.....	()
Apparel:	
Mens apparel.....	()
Womens apparel.....	()
Boys apparel.....	()
Girls apparel.....	()
Sportswear.....	()
Hat, cap, and millinery.....	()
Fur goods.....	()
Gloves.....	()
Robes and dressing gowns.....	()
Raincoats.....	()
Leather clothing.....	()
Curtains and drapes.....	()
House furnishings.....	()
Textile bag.....	()
Canvas goods.....	()
Lumber and wood:	
Logs and poles.....	()
Lumber.....	()
Veneer and plywood.....	()
Wooden containers.....	()
Furniture and fixtures:	
Household furniture.....	()
Upholstered household furniture.....	()
Mattresses and bedsprings.....	()
Office furniture.....	()
Partitions, shelving, and lockers.....	()
Office and store fixtures.....	()
Venetian blinds and shades.....	()
Pulp mill.....	()
Paper mill:	
Paper coated and glazed.....	()
Envelopes.....	()
Paper bags.....	()
Wallpaper.....	()
Paperboard and cardboard.....	()
Pressed and molded.....	()
Sanitary paper goods.....	()
Building paper and boards.....	()
Printing:	
Periodicals.....	()
Books.....	()
Atlas.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Directories.....	()
Patterns.....	()
Business forms.....	()
Greeting cards.....	()
Bank books.....	()
Chemicals:	
Alkalies and chlorine.....	()
Industrial gases.....	()
Dyes and organic pigments.....	()
Inorganic pigments.....	()
Industrial organic chemicals.....	()
Industrial inorganic chemicals.....	()
Plastics and synthetic resins.....	()
Synthetic rubbers.....	()
Synthetic fibers.....	()
Synthetic organic fibers.....	()
Drugs.....	()
Pharmaceutical preparations.....	()
Soaps and detergents.....	()
Specialty cleaners.....	()
Surface active agents.....	()
Perfumes, cosmetics, and toilet preparations.....	()
Paints, varnishes, and allied products.....	()
Gum and wood chemicals.....	()
Agricultural chemicals.....	()
Adhesives and gelatin.....	()
Explosives.....	()
Printing ink.....	()
Carbon black.....	()
Petroleum:	
Refined petroleum.....	()
Paving and roofing materials.....	()
Asphalt felts and coatings.....	()
Lubricating oils and greases.....	()
Rubber:	
Tires and inner tubes.....	()
Rubber footwear.....	()
Fabricated rubber goods.....	()
Fabricated plastic goods.....	()
Leather:	
Tanned and finished leather.....	()
Industrial leather belting and packing.....	()
Boot and shoe leather.....	()
Gloves and mittens.....	()
Luggage.....	()
Handbags.....	()
Personal leather goods.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Nonmetallic minerals:

Glass.....	()
Glass containers.....	()
Pressed and blown glass and glassware.....	()
Cement.....	()
Brick and structural clay tile.....	()
Ceramic wall and floor tile.....	()
Clay refractories.....	()
Vitreous china plumbing fixtures.....	()
Vitreous china table and kitchenware.....	()
Fine earthenware.....	()
Porcelain electrical goods.....	()
Concrete block and brick.....	()
Concrete goods.....	()
Ready-mix concrete.....	()
Lime.....	()
Gypsum.....	()
Cut and dimension stone.....	()
Abrasives.....	()
Asbestos.....	()
Gaskets packing and asbestos insulation.....	()
Minerals and earths.....	()
Mineral wool.....	()
Nonclay refractories.....	()

Primary metals:

Pig iron.....	()
Steel.....	()
Hot rolled steel sheet, strips and bars.....	()
Electrometallurgical goods.....	()
Wire drawn goods.....	()
Cold rolled steel sheet, strips and bars.....	()
Steel pipes and tubes.....	()
Foundry castings.....	()
Nonferrous metal smelting.....	()
Nonferrous metal refining.....	()
Secondary nonferrous smelting.....	()
Secondary nonferrous metal refining.....	()
Nonferrous metal rolling drawing and extruding.....	()
Nonferrous wire drawing and insulating.....	()
Iron and steel forgings.....	()
Nonferrous forgings.....	()

Fabricated metals:

Metal cans.....	()
Cutlery.....	()
Hand and edge tools.....	()
Hand saws and blocks.....	()
Enameled iron and metal sanitary ware.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Plumbing fixture fittings and trim.....	()
Nonelectric heating equipment.....	()
Structural steel.....	()
Metal doors, sashes, and frames.....	()
Boiler plate work.....	()
Sheetmetal.....	()
Architectural and ornamental metalwork.....	()
Screw machine.....	()
Bolts, nuts, screws, rivets, and washers.....	()
Metal stampings.....	()
Electroplated goods.....	()
Engraved goods.....	()
Fabricated wire goods.....	()
Barrels, drums, and kegs.....	()
Safes and vaults.....	()
Steel springs.....	()
Valves and pipe fittings.....	()
Collapsible tubes.....	()
Metal foil and leaf.....	()
Fabricated pipe and fittings.....	()
Machinery:	
Engines and turbines.....	()
Internal combustion engines.....	()
Farm machinery and equipment.....	()
Construction machinery and equipment.....	()
Mining machinery and equipment.....	()
Oil field machinery and equipment.....	()
Elevators and moving stairways.....	()
Conveyors and conveying equipment.....	()
Hoists, cranes, and monorail systems.....	()
Industrial trucks, tractors, and trailers.....	()
Metal cutting machine tools.....	()
Metal forming machine tools.....	()
Dies and tools, die sets, jigs and fixtures.....	()
Machine tool accessories.....	()
Measuring devices.....	()
Metal working machinery.....	()
Power driven handtools.....	()
Food products machinery.....	()
Textile machinery.....	()
Woodworking machinery.....	()
Paper industries machinery.....	()
Printing trades machinery and equipment.....	()
Special industry machinery.....	()
Pumps, compressors and pumping equipment.....	()
Blowers and fans.....	()
Industrial patterns.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Mechanical power transmission equipment.....	()
Industrial process furnaces and ovens.....	()
Office machines.....	()
Computing machines.....	()
Accounting machines.....	()
Scales and balances.....	()
Automatic merchandising machines.....	()
Laundry drycleaning and pressing machines.....	()
Air-conditioning equipment.....	()
Refrigeration machinery and equipment.....	()
Measuring and dispensing pumps.....	()
Service industry machines.....	()
Electrical machinery and equipment:	
Measuring instruments.....	()
Test equipment.....	()
Power distribution equipment.....	()
Switchgear and switchboard apparatus.....	()
Motors and generators.....	()
Industrial controls.....	()
Welding apparatus.....	()
Carbon and graphite goods.....	()
Industrial apparatus.....	()
Household appliances.....	()
Household laundry equipment.....	()
Electric housewares and fans.....	()
Household vacuum cleaners.....	()
Sewing machines.....	()
Electric lamps.....	()
Lighting fixtures.....	()
Current carrying devices.....	()
Noncurrent carrying devices.....	()
Radio and TV sets.....	()
Signalling and detection equipment.....	()
Electron tubes.....	()
Cathode ray picture tubes.....	()
Transmitting and industrial electron tubes.....	()
Semiconductors and related devices.....	()
Electronic components.....	()
Storage batteries.....	()
X-ray apparatus and tubes.....	()
Electromedical apparatus.....	()
Electrotherapeutic apparatus.....	()
Automotive electrical equipment.....	()
Transportation equipment:	
Motor vehicles.....	()
Motor vehicle parts and accessories.....	()
Aircraft.....	()

SPECIALIZATIONS IN INSPECTION AND TESTING (Continued)

Aircraft engines and parts.....	()
Aircraft propellers and parts.....	()
Aircraft auxiliary equipment.....	()
Ships.....	()
Boats.....	()
Locomotives and parts.....	()
Railroad and streetcars.....	()
Motorcycle, bicycle and parts.....	()
Trailer coaches.....	()
Instruments:	
Engineering.....	()
Laboratory.....	()
Scientific and research.....	()
Mechanical measuring and controlling.....	()
Orthopedic, prosthetic, and surgical appliances.....	()
Dental equipment and supplies.....	()
Ophthalmic goods.....	()
Photographic equipment and supplies.....	()
Watches, clocks, clock operated devices.....	()
Watch parts.....	()
Jewelry.....	()
Precious metal jewelry.....	()
Jewelry findings.....	()
Lapidary goods.....	()
Silverware and plated ware.....	()
Musical instruments.....	()
Toys and games.....	()
Dolls.....	()
Childrens vehicles.....	()
Sporting goods.....	()
Pens and pencils.....	()
Marking devices.....	()
Carbon paper and inked ribbons.....	()
Costume jewelry.....	()
Artificial flowers.....	()
Buttons.....	()
Needles, pins, hooks, and eyes.....	()
Brooms and brushes.....	()
Signs and advertising displays.....	()
Mortician goods.....	()
Linoleum and hard surfaced floor coverings.....	()
Others (Specify).....	()

MACHINES, TOOLS, EQUIPMENT AND WORK AIDS

Machines:

Centrifuges.....	()
Pumps.....	()
Bend fatigue machines.....	()
Vibrators.....	()
Separators.....	()
Hydraulic presses.....	()
Air compressors.....	()
Vibratory screens.....	()
Hardness testers.....	()
Burst testers.....	()
Other (Specify).....	()

Tools:

Handtools:

Drills.....	()
Chisels.....	()
Files.....	()
Knives.....	()
Rules.....	()
Scissors.....	()
Tapes.....	()
Scribes.....	()
Sidecutters.....	()
Wirecutters.....	()
Wire strippers.....	()
Levels.....	()
Awls.....	()
Pliers.....	()
Screwdrivers.....	()
Brushes.....	()
Wrenches.....	()
Stylus.....	()
Clippers.....	()
Needles.....	()
Squares.....	()
Other (Specify).....	()

Equipment:

Driers.....	()
Ovens.....	()
Furnaces.....	()
Scales.....	()
Torsion balance scale.....	()
Balance scales.....	()
Analytical scales.....	()
Fractional distillation equipment.....	()
Magnaflux equipment.....	()

MACHINE, TOOLS, EQUIPMENT AND WORK AIDS (Continued)

Ultrasonic test equipment.....	()
Other (Specify).....	()
Work Aids:	
Mechanical measuring devices:	
Calipers.....	()
Verniers.....	()
Dividers.....	()
Bevel protractor.....	()
Protractor.....	()
Gauges:	
Center gauge.....	()
Feeler gauge.....	()
Balance gauge.....	()
Height gauge.....	()
Pressure gauge.....	()
Plug gauge.....	()
Radius gauge.....	()
Screw pitch gauge.....	()
Surface gauge.....	()
Telescoping gauge.....	()
Thickness gauge.....	()
Go No-go gauge.....	()
Thread gauge.....	()
Wire gauge.....	()
Pin gauge.....	()
Ball gauge.....	()
Micrometers:	
Depth micrometer.....	()
Flange micrometer.....	()
Inside micrometer.....	()
Outside micrometer.....	()
Swiss hole micrometer.....	()
Electronic micrometer.....	()
Gauge blocks:	
Johanason blocks.....	()
Parallel blocks.....	()
V blocks.....	()
Sine bars.....	()
Angle plates.....	()
Quadrants.....	()
Straight edges.....	()
Footage counters.....	()
Yardage counters.....	()
Depth rules.....	()
Shrink rules.....	()
Machinist rules.....	()
Surface plate.....	()
Other (Specify).....	()

MACHINES, TOOLS, EQUIPMENT AND WORK AIDS (Continued)

Testing equipment:

Meters:

Watt meter.....	()
Potentiometer.....	()
Moisture meter.....	()
Monometer.....	()
Tachometer.....	()
Focimeter.....	()
Galvanometer.....	()
Demitron meter.....	()
Callimator.....	()
Goniometer.....	()
Dynanometer.....	()
Extensometer.....	()
Tensiometer.....	()
Torque meter.....	()
Conductometer.....	()
Flow meter.....	()
Frequency meter.....	()
Megohmmeter.....	()
Sacchrimeter.....	()
Colorimeter.....	()
Ammeter.....	()
Ohmmeter.....	()
Power factor meter.....	()
Phase angle meter.....	()
Voltmeter.....	()
Voltohm milliammeter.....	()
Photometer.....	()
Electrophotometer.....	()
Refratometer.....	()
Ph meter.....	()
Reflectometer.....	()
Electropyrometer.....	()
Radiometer.....	()
Vapor fractometer.....	()
Light meter.....	()
Spectrophotometer.....	()
Hydrometer.....	()
Plastometer.....	()
Durometer.....	()
Densimeter.....	()
Thermometer.....	()
Perimeter.....	()
Carbon analyzer.....	()
Color machography equipment.....	()
Spectrum analyzer.....	()

MACHINES, TOOLS, EQUIPMENT AND WORK AIDS (Continued)

Circuit continuity equipment.....	()
Megohm bridge.....	()
Kelvin bridge.....	()
Wheatstone bridge.....	()
Impedance measuring equipment.....	()
Microwave testing equipment.....	()
Oscillograph.....	()
Osilloscope.....	()
Metallograph.....	()
Optical compator.....	()
Polariscope.....	()
Shadowgraph.....	()
Transit.....	()
Optical protractor.....	()
Binocular microscope.....	()
Magna gauge.....	()
Steromicroscope.....	()
Stroboscope.....	()
Monoscope.....	()
Cyroscope.....	()
Power determining instrument.....	()
Optical centering instrument.....	()
Stress strain recorders.....	()
Pneumatic test equipment.....	()
Hydrostatic test equipment.....	()
Other (Specify).....	()
Miscellaneous Work Aids:	
Standard samples.....	()
Formulas.....	()
Approval slips.....	()
Rejection slips.....	()
Inspection orders.....	()
Samples.....	()
Records.....	()
Graphs.....	()
Tables.....	()
Specimens.....	()
Specifications.....	()
Test sheets.....	()
Holding devices.....	()
Jigs.....	()
Fixtures.....	()
Master samples.....	()
Color samples.....	()
Specifications manual.....	()
Blueprints.....	()
Sketches.....	()

MACHINES, TOOLS, EQUIPMENT AND WORK AIDS (Continued)

Plumb bob.....()
Magnifying glass.....()
Timing light.....()
Other (Specify).....()

Unit 1
HISTORICAL BACKGROUND OF QUALITY CONTROL

OBJECTIVES

1. To make the students aware of the evolution of quality and the act of inspection.
2. To provide the student with general knowledge allowing a greater perspective of the field and factors which influence it to be understood.
3. To provide the student with a means of integrating related knowledge into the quality control field.

TEACHER METHOD CONTENT

1. Discuss quality, control and inspection broadly as used/interpreted throughout history.
2. Discuss apprenticeship, craft guilds and AFL/CIO contributions.
3. Discuss what quality means, broadly and specifically.
4. Discuss interrelated factors which affect quality.
5. Discuss how quality operations integrate various factors into its system, program or structure.

LEARNING RESOURCES

1. Standard history course program materials.
2. External resource personnel.
3. Standard References: Quality Control Handbook: Ed.; J. M. Juran; McGraw-Hill, New York, 2nd Edition; 1962.

EVALUATION

1. Instructor and/or resource personnel observations.
2. Instructor and/or resource personnel self-made tests.

NOTES FOR THE INSTRUCTOR: HISTORICAL BACKGROUND OF QUALITY CONTROL

An overview of quality control principles, concepts, methods of inspection and testing reveals a consistency with occupations in other-systems throughout history. Early non-formalized inspec-

tion and testing occurred constantly as man made weapons and tools to his own specifications and tested them by usage. Early inspection and testing was practiced in food identification, acquisition and preparation. An early form of quality control was developed immediately after new food was found to be poisonous.

Quality control, in a wider interpretation, was sociologically and psychologically based in the writings and practices of moral, ethical and religious codes and the socialization of tribes, clans or races.

Quality control in the work of production areas are known to have existed as far back in history as writings can be found. Apprenticeship history is, largely, the story of knowledge and skill learned in pursuit of the attributes of fineness, beauty, art and/or high quality. These were linked, generally, to the terminology "pride of workmanship." To this day, that terminology is still utilized to express the quality dimension.

The term quality control seems to have appeared, formally, in the early 20th Century. As the various global societies encountered and participated in the Industrial Revolution, quality control became more systematic resulting in a science incorporating changing philosophy, rationale, concepts and methodology to meet the influences of the modern Industrial Revolution.

Today, there is great concern about what quality means, how it is obtained and assured and whether or not it can be economical. The following sections will provide historical perspective, economic bases of quality control, affects and effects of mass production influences and information about the quality assurance/quality control career field.

During the very early history of primitive man, the necessity for tools, weapons, shelter, clothing, heat and food had priority purpose over control. The purpose was inspection and test, first, rather than having quality control. This functioned as making one of a kind, or a few items as they were needed or when they were needed. Thus, early apprenticeship education and training programs started similarly making things different or distinct which was the major characteristic desired, not replication of the same item. The formality of quality was developed by transference of knowledge and skills from the master craftsman to the apprentice. This was a very secret operation and later in history was formalized by incorporating the masters and apprentices in craft guilds, an early form of unionization.

Later, during early and middle stages of the Industrial Revolution, some phases of mass production were contemplated and began. At this point, quality control began. The making of

limited multiples of items started with very rough specifications and controls. Slowly, with a growing demand for more and different kinds of goods and services, there came a specialization of labor, knowledges and skills.

The apprentice generalist slowly narrowed down his competency-range field to produce what he did best and that which he could obtain more satisfaction, money and status. With the specialization factor introduced into the production enterprise, the necessity for more apprentices and supporting workers appeared. Accompanying this expanding work force was quality control, a methodology of assuring consistency.

At the turn of the 20th Century, quality control was being explored, expanded and in operation. Later, during the 1920's, the first major and formal programs were designed, attempted and evaluated. At that point in time, quality control was not yet considered to be what we now know as industrial engineering. Controls and specifications were then a function of division of labor, production rates (time, efficiency) and technological capability.

Later, in the 1930's, mass production influences and the increase of many unskilled jobs caused quality control to be considered more seriously in terms of its need versus the cost of having such a sub-function within any enterprise. The acceptance of formal quality control led to one other major influence, the use and development of mathematics and statistics in the control and measurement dimensions.

While mathematics and statistics had been widely used by scientists, engineers, businessmen (finance) and insurance companies (actuarial sections), application to prediction and control mechanisms within the manufacturing enterprise had not been utilized until quality control became both a standard method of operation from the 1930's until the present. The use of quality control is now an accepted procedure in production matters.

The public is becoming more aware and concerned with quality and quality control. In general, the population wants the quality of life improved; the quality of air improved; the quality of products improved and the quality of all areas of human endeavor to improve. A distinction must be made between quality, in the abstract/general usage, and quality control. Quality control is accomplished with a performed standard against which the end product is measured and evaluated. Only when the specification is established can control be contemplated. Control can only be established when the capabilities of the change or production agent are known and suitable for the purpose.

Quality, as such, does not exist as a separate entity. It is something determined by a viewing agent. Quality can be thought of as an asset. A certain "rock" has a certain quality. We may not accept that particular quality or we may ignore that dimension altogether, or we may like it.

Part of the attribute quality has is its worth, value of utility to the observer or owner. The (aesthetic) rock can be made a decoration in the garden or home. It can be changed in shape or texture or color by "operating" on it, making small new forms, making a statue or polishing it or cutting it to reveal inner lattices. The quality will change, i.e., that which we determine its quality to be.

However, should we decide to change or shape many rocks like this, and want the same qualities to appear each time (consistency), we would have to control the operations that accomplish this and measure the end result. This would be quality control in operation. Present day influences which affect quality control and inspection and testing are the factors of:

- Politics - organization of society and expressing of needs, wants and desires through laws, regulations, standards and rules.
- Economics - assignment and utilization of resources (men, machines, materials, money and time) in pursuit of quality.
- Technology - improving capability to attain desired and/or wanted quality levels.
- Sociology - organization of society and its influences on wants, needs and desires on political, economic and technologic factors.

The posture of quality control is sometimes quite complex and often misunderstood. Actually, quality control personnel can be thought of as the consumer's representative working in the producer's plant. Today, this viewpoint is becoming more visible and acceptable.

Unit 2
ECONOMIC BASES OF QUALITY CONTROL

OBJECTIVES

1. To provide the student knowledge of economic influences at work in quality control functions.
2. To provide the students with economic knowledge and its form of utility in quality control operations.
3. To provide to students knowledge of economic vs. production capability constraints.

TEACHING CONTENT

1. Discuss why a program or system of quality control has a basis in economics. (organization and purpose)
2. Discuss why quality and economics are at odds in purpose. (producer vs. consumer views)
3. Discuss when quality and economics are aligned in purpose. (producer and consumer congruity)

LEARNING RESOURCES

1. Standard economic course program materials.
2. External resource personnel.
3. Standard reference: (See sources of information)

EVALUATION

1. Instructor and/or resource personnel observations.
2. Instructor and/or resource personnel self-made tests.

TEACHER NOTES: ECONOMIC BASES OF QUALITY CONTROL

Quality control systems can be costly. Every product made can be produced of the highest quality material obtainable, but few persons could afford them, and not many products can be produced at low cost.

Workers are hired and given jobs to produce products made to specifications. It seems unnecessary to have to control the worker's method and techniques. However, in order to produce products, in enough quantity, and at an affordable price, a certain level of quality will have to be acceptable or negotiated as satisfactory to the consumer as well as to the producer.

Finding out what factors of quality are assessed and measured by the consumer is necessary in order to make the product desirable/purchasable in an economic sense.

If items are produced with a high level quality-index, the cost of producing them may limit the market which will buy them, even though they are desired (\$250,000 homes; Ferrari automobiles). If items are produced with low quality and available to many people, the products will, usually, be rejected or not even bought after a few are tried out (dime-store eyeglasses).

Somewhere in this range from high cost high quality to low cost low quality extremes, a quality index is established which is acceptable for each product. Basically, this is an economic decision made by both the producer and customer, ideally in concert (by market surveys, customer precomplaints) but usually unilaterally, by the producer or the consumer.

The producer has immediate constraints and limitations before producing any item. They are laws, rules, regulations, from government and internal policies. The producer can afford only a certain number of workers and how they are utilized in fulfilling certain functions determines whether the enterprise succeeds or fails.

The consumer has immediate constraints also. Governmental laws prohibit purchase of certain products; cultural factors prohibit purchase of certain products; a customer has a limited amount of purchasing power to buy all that is needed, wanted and/or desired. The problem to be solved is a double viewpoint problem, but with the same result. Usually it is stated as:

Producer Viewpoint: How to produce the least expensive item that will do what is required;

Consumer Viewpoint: How to select and buy the least expensive item that will do what is required.

The main agreement is not money, but the meaning of what is required.

A customer wishes to purchase a car for \$3,000 which will last 25 years. A producer cannot make it at that price. However, a producer can make a \$7,000 car that will last 7 years.

Basically then, a compromise of what is required must take place. A customer may give up 10 years of a car-life if the producer will guarantee trouble free operation for 5 years. A producer may cut the price \$200, if the customer will not need a 350 horsepower engine, and so forth. Finally, a compromise is reached on a car which costs \$3,800 and will last 5 years.

While the decision was not entirely economic, (i.e., style preference and status went into the decision) somehow, all the factors were reduced to money-terms and the decision ended up as being economic in nature. Therefore, the genesis of quality control is economics. Some of a producer's resources must be devoted to maintaining quality operations in order to sell a product. This cost is passed on to the consumer, as is the costs of labor and materials.

The more difficult matter to resolve is the necessity for quality control if all workers perform their functions as specified. Obviously, it must be that all workers do not perform their jobs satisfactorily and/or there is a mismatch between workers and the jobs or tasks they are expected to do. This is a very serious and complex problem. There is little doubt that pride of workmanship, historically preserved by the earlier craft guilds and unions is important. The specialization aspects of the division of labor, constancy of mass production schedules and changing philosophy about work have all contributed to the problem of maintenance of pride in workmanship.

The basis and need for quality control, inspection, and test career fields is simple. The world is probabilistic and not deterministic. Murphy's Law reigns: "What ever can go wrong, will!" This is not to say that there are not causes, but there are many complex causes not prevented by physical measurement of inspection or establishing policies.

A condition once quite prevalent in manufacturing enterprise was to pay a worker by "piece-work;" i.e., the number of pieces produced at so much money per piece determined the pay the worker received. Early attempts at quality control also deemed that, if a piece were damaged or rendered unusable during an operation, the worker paid for it at the rate of its dollar-worth at the time of its manufacture.

Unions have worked with management so that today the general philosophy has changed regarding piece-work. It is still retained, to a small degree, however, by some industry.

Again, a compromise seems to exist between having a perfect and competent work force with no quality control and an incompetent work force with 100% quality control.

There is no perfect work force; technological change precludes working long enough to "get-all-the-bugs-out;" many workers are not that interested in the corporation or what they do in its behalf; the same is true for the corporation--they express too little interest in the workers; skill and education requirements

are not "coldly" established for doing many jobs and they are, many times, experimental in nature; the degree of machine capability is not adequate for the quality levels desired; and not enough is known about what is desired or needed to completely specify the product and what it must, should or can do.

Quality control begins at the management level. At the time policies are made, a statement of quality is made and accepted. It is an economic decision, and a complex one.

OBJECTIVES

- ## TEACHING CONTENT

- ## LEARNING RESOURCES

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3. "Human Values and Work in American Life;" in Man in a World, Ed.; H. Borow; Houghton-Mifflin, Boston. 1964, pp. 24-44.
4. Labor and management resource personnel.

EVALUATION

1. Instructor and/or resource personnel observations.
2. Instructor and/or resource personnel self-made tests.

TEACHER NOTES: THE AFFECT/EFFECT OF MASS PRODUCTION INFLUENCES

Quality control procedures do not produce products or items. It is difficult to say that its procedures contributed dollars to the industry.

The engineering and support functions design the quality control system and with the factory function, operate it.

Quality control encompasses such things as management information systems; management correspondence, economic and financial reports; reporting format and content; data processing system design and operation; legal interpretations of contracts and compliance to contractual matters; selection hiring and training of personnel; providing and receiving information from sales and marketing about product quality; supplying data and information and data from various engineering or factory sub-functions concerned with design, development operation and test of products and systems.

All of these operations, while complex in scope, can, in fact, be reduced to economic terms. Quality control, inspection and test personnel work in all of the above listed sub-functions affecting the economic vein, primarily.

Mass production techniques and methods create the need for quality control operations. A main affect creating the necessity for quality control is the need for standardized parts. Standardized parts are produced more economically and interchangeably. This avoids many different but similar parts being made which can do, at least, many of the same things. The need for exact replication means controls must be initiated. When the parts are specified as "standard" and the control, inspection and test methods and techniques are, likewise, specified standard, then the parts can be made by other industries, not just one. This, also, promotes free enterprise and competition among all industries.

An effect of quality control in the mass production process is that of feedback from the control process. Feedback is in the form of information and/or data for:

1. Value Engineering - helps to reduce item costs by respecifying tolerances and materials, while still maintaining performance of product.
2. Tools/Equipment Engineering - helps to determine life-capability of production machinery and tools.
3. Design and Production Engineering - helps to identify changes in components, materials and manufacturing processes which will make product better.
4. Management - supplies data and information about operating quality characteristics, both in-house and from customers.

There is a constant affect-effect relationship as quality control, inspection and testing operate within the production enterprise. Other items are worth noting, as well:

1. Many times quality control, inspection and test personnel are viewed as policemen and not well-accepted by production or engineering personnel.
2. Most personnel do not understand the authority and responsibility of quality control, inspection and test personnel.
3. Quality control personnel must be honest and reliable and report accurately and as objectively as possible. Failure to do this diminishes the entire concept of quality, and purposes of quality control.

The larger mass production enterprises are, the more effective quality control, inspection and test must be. Thousands of parts or products can get out before a defect is recognized if the controls are not constant in operation. The necessity and cost of setting up special "fix-it" lines and/or recalls is related to the effectiveness of the quality control organization.

Obviously, the factory personnel are not making low quality products on purpose. The machine operators and assemblers are doing a quality control function as they work. No system called quality control can take credit for product quality. They can take partial credit for seeing that it is maintained. Quality is put into the product by the worker. It is measured by quality control. The complexities of this function is in direct proportion to the size of the organization and the degree of mass production encountered.

Unit 4
SYSTEMS TECHNOLOGY AND QUALITY CONTROL

OBJECTIVES

1. The student will be able to identify major system components and use general systems terminology.
2. The student will be able to identify and relate various occupational and job knowledge and skills in systems engineering activities.

TEACHING CONTENT

1. The instructor should discuss what is meant by system and give examples. (Home-Furnace Thermostat)
2. The instructor should select an exemplar system and have the students attempt to:
 - a. determine its need
 - b. determine its required (specified) performance
 - c. determine its costs
 - d. determine the resources necessary (functions, processes, products)
 - e. determine how to test it
 - f. determine whether to accept, reject or modify.

NOTE: Additional systematic activities could be utilized herein. The work and/or process flow-chart could be used as a system; A PERT chart could be made and used as a system example.

LEARNING RESOURCES

No particular reference is made due to the specialization and sophistication in most formal systems engineering books. Any type enterprise can be considered a system and investigated, interrogated and analyzed.

At this point, the instructor can utilize the generic and discrete models contained in the guide under the heading generalized instruction model as the framework for systems purposes.

Any resource would do for the object lesson: a dress, a car, a home, parts of larger systems, etc., and/or the quality control system.

EVALUATION

1. Instructor observation and discussion with students.
2. Instructor interpretation of student effort, roles, skills and knowledge vis a vis a system design accomplished.
3. Instructor self-made tests.

TEACHER NOTES: SYSTEMS TECHNOLOGY AND QUALITY CONTROL

BACKGROUND INFORMATION

Systems technology is the knowledge we have collected about systems, their performance and their characteristics. For a system to exist, it must have a purpose, a mission, or a task that it can perform.

The American Society for Quality Control defines a system as:

"A group of interacting human and/or machine elements, directed by information, which operate on and/or direct material, information, energy, and/or humans to achieve a common specific purpose."

Examples of systems are listed below for teacher/student discussion. Typical systems are:

- | | |
|---------------------------|------------------------------|
| 1. Solar system | 6. Communication systems |
| 2. Stellar system | 7. Educational systems |
| 3. Economic systems | 8. Distribution systems |
| 4. Political systems | 9. Aerospace systems |
| 5. Transportation systems | 10. Quality Control systems. |

The reasons for stressing the system concept to interested students are aptly presented by A. V. Feigenbaum in an article titled Major New Developments in Systems Engineering. He stated that engineered systems are better for the following reasons:

1. They operate at optimum speed and with optimum response.
2. There is harmony among its human elements.
3. They integrate human and machine elements.
4. They provide higher output/input productivity.
5. They provide output optimization.
6. They provide economy of operation.
7. They allow overall control of action.
8. They influence higher reliability.
9. They provide for effective maintainability.

A manufacturing system consists of eight major stages as described by A. V. Feigenbaum. They are:

Marketing	Manufacturing Supervision and
Engineering	Shop Operations
Purchasing	Mechanical Inspection and
Manufacturing Engineering	Functional Test
Shipping	Installation and Service.

QUALITY CONTROL SYSTEMS

In the field of quality control, which is in itself a system, there are specific definitions also. One of these definitions was listed by A. V. Feigenbaum in Total Quality Control. It stated:

"The quality system is the network of administrative and technical procedures required to produce and deliver a product as specified quality standards."

The key elements of a quality system as described by A. V. Feigenbaum are as follows:

1. Production Quality Evaluation - The establishment of procedures to analyze formally both the product design and the process design to ascertain that the resultant product will fulfill the customer's requirements.
2. Product and Process-Quality Planning - The formalizing of plans to measure, attain, and control the desired product quality.
3. Purchased-Material Quality Planning, Evaluation and Control - Provides the procedures necessary to control purchased material.
4. Product and Process-Quality Evaluation and Control - The procedures established for implementing the product and process-quality planning.
5. Quality Information Feedback - The information system which forms a part of the quality system.
6. Quality Information Equipment - The equipment that provides the quality measurements that are necessary for the control of quality identified during product and process quality planning.

7. Quality Training, Orientation, and Manpower Development - Provides the means for developing the people capability required to properly operate the quality system.
8. Postproduction Quality Service - The service provided to ensure the consumer a product will function as expected.
9. Management of the Quality Control Function - The procedures the manager uses in getting his job of managing done.
10. Special Quality Studies - Provides procedures and techniques for identifying specific quality problems and finding specific solutions for such problems.

The quality system provides the channels through which the stream of product-quality-related activities flow. This, together with other systems, makes up the main line flow of the total business system.

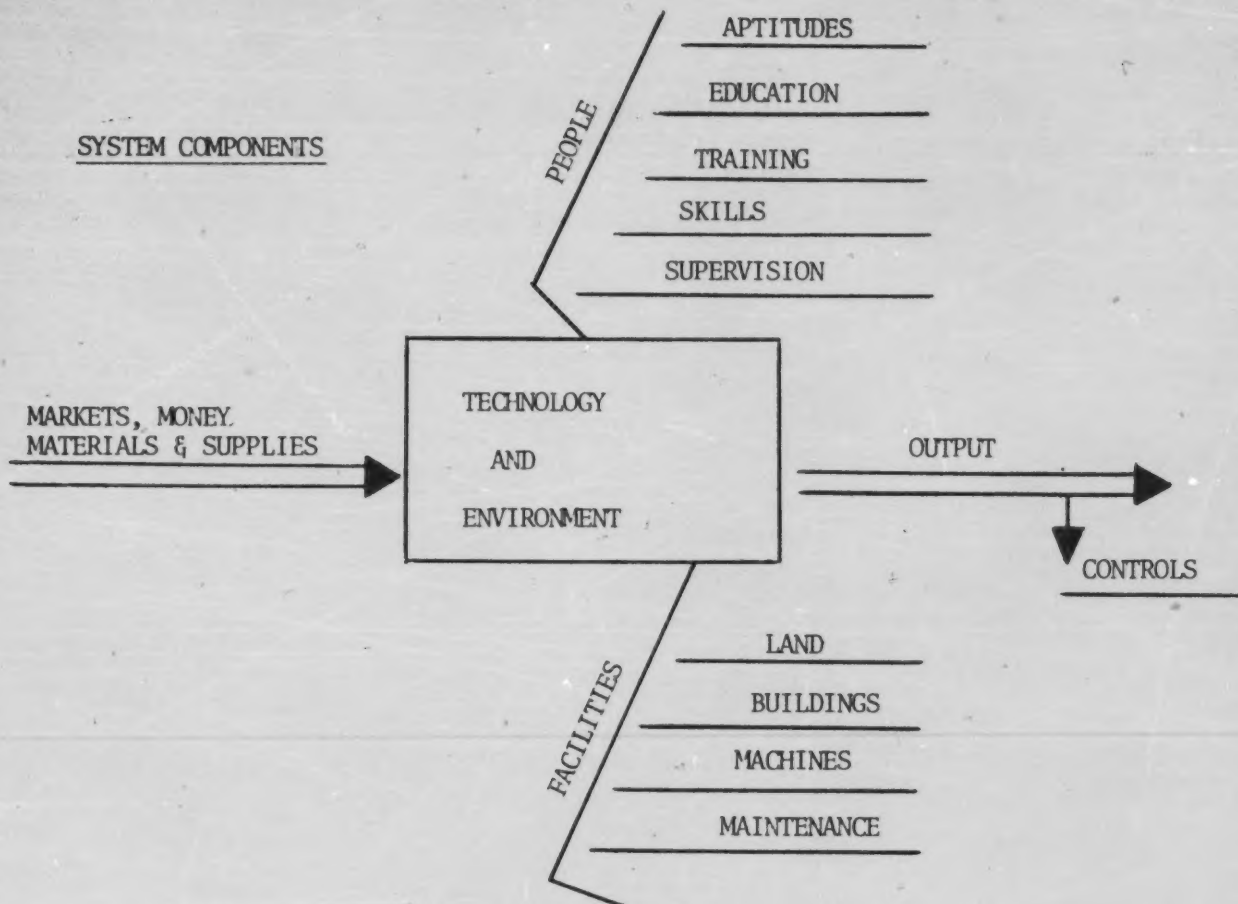
THE MANUFACTURING PROCESS AS A SYSTEM

Incorporating the stages of a manufacturing system into a controllable function requires an understanding of the fundamental factors that affect quality. These six basic factors are:

Markets
Men
Money

Management
Materials
Machines and Methods

The following diagram shows the general construction of a model for a manufacturing system.



The following factors must be considered in the manufacturing process at all times:

1. Technology - Includes the selection of the product to be manufactured and the process by which it is produced.
2. Resources - Include the materials and parts used to make the products and the power and fuel required to operate the production machines.
3. Facilities - Include the machines and equipment used to produce the product.
4. Buildings - To house the people and equipment.
5. Maintenance - Keep the facilities operating and in good condition.
6. Labor - The people who operate the machinery and run the factory. They require: aptitude, education, training, and skills.

Unit 5
STATISTICS IN QUALITY CONTROL

OBJECTIVES

1. The student will be able to be an intelligent consumer of statistical information.
2. The student will acquire general interpretive skills related to selected common distributions.
3. The student will be able to understand the usage of statistics in quality control and inspection activities.
4. The student will acquire selected skills and knowledge related to ordering, reducing and analyzing statistical information.

TEACHING CONTENT

1. The instructor should define the word statistic and what statistics means.
2. The instructor should discuss how prevalent the usage of "statistics" is in all walks of life.
 - a. government usage
 - b. advertising/selling
 - c. consumer reporting
 - d. quality control
3. The instructor should show and explain distributions and how they are used to derive work-charts or other statistical references used by industrial personnel: Engineers, Data Processing Personnel, Quality Control and Inspection Personnel.

LEARNING RESOURCES

1. Fun With Figures; F. Moroney; Penguin Pocket Books, Baltimore, Maryland.
2. Mathematics for the Millions; L. Hogben; Bantam Books, New York.

EVALUATION

1. The instructor can observe and discuss the examples and problems with the students, determine their understanding and capabilities.

2. The instructor can utilize self-made tests.

TEACHER NOTES: STATISTICS IN QUALITY CONTROL

THE NEED FOR STATISTICS

One of the most important tools used by the quality control specialist is the mathematics of statistics and probability. Statistics is a technical word for the study of the results of such actions as tossing a coin, throwing a pair of dice or playing a card game. The concept of "playing the odds" has fascinated humans since the beginning of time. But the practical use of statistics is a relatively recent development, with its primary growth during the Twentieth Century. Statistics are used in medicine, education, research, business and economics.

The principal value of statistics is its application to the analysis of data and information obtained from a small sample. The data obtained from this sample can be a very accurate measurement for the entire population or group from which the sample was taken. The use of polling techniques to predict elections and the use of computers to predict the outcome on election night are examples of statistical applications. Television programs are rated based on a statistical sampling of about 1,000 families randomly selected throughout the United States (Nielsen Ratings). From this sample of families and some supplemental telephone surveys, the analysts are able to estimate the television viewing habits of all the families in the United States.

When referring to quality control by statistical methods, it is meant specifically to those quality control techniques which involve the use of statistical data. The term "statistics" has caused a great deal of consternation in industry since it is generally associated with highly involved theories and mathematics. However, the student should realize that statistical methods in daily industrial use have been reduced to very elementary arithmetic and may be substantiated by simple logical deduction.

There are three basic areas of concentration to which statistical quality control techniques are generally applied. They are:

Process Controls Acceptance Techniques Special Job Studies

1. Process Control

As material is processed, samples are taken and inspected. Based upon the results of these inspections, the process is either judged to be operating in a normal fashion or subject to unusual conditions. This decision is based

upon the interpretation of a quality control chart. The control charts may be divided into two categories--those for variable and those for attribute data.

Whenever the inspections involve a numerical classification of a quality characteristic, the data is said to involve variables. When a diameter is recorded in inches, hardness in Rockwell units, chemical contents in percentages, or an angle in degrees, the data is recorded as a variable. If a part is simply judged good or bad, the data is recorded in terms of attributes. The material is either the proper hardness or it is not, the chemical content is either acceptable or it is not, the weld either exists or it does not, the finish is either smooth enough or it is too rough. These classifications provide data in attribute form.

- a. X-R Charts: These charts are for variable data.
- b. p, np, and c Charts: These charts are for attribute data.

Quality control charts provide their greatest benefit by detecting, at the earliest possible time, conditions which cause defective material. Thus, a process may be corrected before it produces large quantities of borderline or defective material.

2. Acceptance Sampling

Acceptance sampling techniques are designed to permit valid decisions on material to be based upon a relatively small sample. This allows inspection of a sample of the parts and a possibility to decide upon this evidence whether or not the entire group of parts is satisfactory. Most of the acceptance plans which are gaining the widest acceptance are the Military Standard Sampling Procedures and Tables for Inspection by Attributes, or MIL-STD-105D, the international designation of which is ABC-STD-105.

3. Special Job Studies

Very often certain quality information is desired which is not available from the control charts and acceptance techniques in use. Special statistical techniques may be used to analyze the data collected. This may involve special applications of the control chart techniques or may involve other more advanced statistical techniques.

Some of the more common studies might involve the determination of process capabilities, the review of existing specifications, the investigation of the relationship of various chemical or physical properties of a material to some formed dimension, and the comparison of certain alternate processes.

Benefits that are obtained from statistical quality control are listed as follows:

1. Prevents unnecessary inspections.
2. Provides facts for decision making.
3. Improves inspection methods.
4. Improves flow of material.
5. Stimulates quality-consciousness.
6. Influences vendor goodwill.
7. Improves product quality.
8. Allows process capabilities information.
9. Reduces scrap.

BASIC STATISTICAL METHODS

For the student who will be at the entry level in the manufacturing industry, only a few of the basic statistical methods should be necessary. These mathematical tools are:

Average:	A measure of central tendency. It is the arithmetic mean of the observed values.	
Range:	A measure of variation. It measures the spread of the distribution.	
Distribution:	Observed values will be distributed about an average. These are approximately the same number of values above and below average. Some of the common distribution curves used in industry are:	
	Normal	Exponential
	Poisson	Rectangular
	Students "t"	Bathtub
	Chi square	
Standard Deviation:	A measure of dispersion of a normal distribution.	

Control
Charts:

Charts used to plot inspection data collected from the manufacturing process being monitored. This type of chart is the most widely used in industry for variable data collection. Some practical applications are:

Temperatures of iron, furnaces, air.
Strength tests on products.
Volumes of containers.
Weights of packaged goods
Moisture contents of lumber.
Sizes of formed dimensions.
Chemical analyses of materials.
Finishes of metals or glasses.

Sampling:

When a random selection of parts are made from a group or lot of parts and inspections are made on these few to determine acceptance or rejection of the entire lot.

Frequency
Distribution:

A tabulation of distribution data shown in graphic form such as the normal curve or a histogram.

THE USE OF STATISTICS IN INDUSTRY

Departments in manufacturing companies usually concerned with the statistical data forms mentioned, especially the control charts, are:

Inspection or Quality Control - Collects the data, tabulates and charts the information, analyzes the data, and makes the interpretations concerning the conformance.

Production Department - Responsible for the adjustment and repair of the process and the supervision of the operators who actually control or operate the production equipment. It is responsible for the quality of the product.

Methods Department - Responsible for providing adequate tools, fixtures, etc. It is involved in decisions regarding machine repairs which are realized through control chart studies.

Design - Study the process capabilities relative to necessary specification tolerances that could result in a change of specification.

Other Departments - Almost all departments associated with manufacturing and service will at one time or another take action which has been directed from the findings of the control chart. Machine replacements, material changes, and personnel changes are all possible results of quality control investigations.

The industrial use of statistical data by the departments listed is made necessary because of production variations. Variations are differences in the results of subsequent samples that are caused by three variations:

1. Variations due to sampling fluctuation.
2. Variations due to process change.
3. Variations due to faulty inspection techniques.

It is because of these variations that the manufacturing industry needs trained quality control personnel with adequate training of the entry level high school student.

Unit 6

AN OVERVIEW OF INSPECTION AND MEASUREMENT

Note: This unit is an overview and contains general knowledge which will be detailed later in program development.

This material is presented as a preview of what type functions, areas and tools and equipment will be utilized by Inspectors in Mechanical, Electrical and Chemical work areas.

In this unit, the information is background type general information and should have influence on student interest in continuing enthusiastically, moderately, or dropping out. Usually, the students will be saying or thinking:

1. Do I want to work in those type industries?
2. Do I want to work in that type clean-dirty job?
3. Do I want to use tools and equipment like that?
4. How did I do in school mechanics, electricity and/or chemistry and what does that mean in this type program?

The specific objectives of: identification of selected tools and equipments per process and work activities; acquisition of skills and knowledge about and in their usage, will be obtained later in the Skills Development section.

AN OVERVIEW OF INSPECTION AND MEASUREMENT

There are many different aspects of quality control in manufacturing that require basic skills relative to various inspection techniques. This section will explore the different inspection types and the respective tools used in industrial measurement.

TYPES OF INSPECTION

There are a wide range of inspection classifications in industry. Some of the general types are:

1. Source Inspection - The inspection of hardware at the source of production. Usually occurs when the purchaser does not have the adequate testing and/or inspection facilities.
2. Incoming Material Inspection (Receiving Inspection) - Inspections performed at the purchaser's plant to determine if material conforms to purchase order requirements.

3. Normal Inspection - When there is no significant evidence that the quality of product being submitted is better than or worse than specified requirements.
4. In-Process Inspection - Inspection which is performed during the manufacturing or repair cycle in the effort to prevent defectives from occurring and to inspect the characteristics and attributes which are not capable of being inspected at final inspection.
5. First Article Inspection - Complete inspection of the first article produced or received.
6. Qualification Inspection - Examination and testing as required in an individual specification to determine whether a product is satisfactory for listing on a qualified producers list.
7. Inspection by attributes - Inspection wherein the unit of product is classified as defective or nondefective with respect to a given requirement or set of requirements.
8. Inspection by Variables - Inspection wherein a specified quality characteristic in a unit of product is measured on a continuous scale.

Other important inspection factors are:

1. Inspection Level - Used to indicate the relative number of sample units for a given amount of product. All other things being equal, a higher inspection level entails a lower risk of acceptance of a lot of inferior quality.
2. Inspection Lot - A collection of units of product from which a sample is drawn and inspected to determine compliance with the acceptability criteria.
3. Inspection Status - A classification of an item as being inspected, withheld, rejected, or accepted with conditional limitations.
4. Inspection Tests - Demonstrate that an article conforms to the established requirements with respect to function, workmanship, and materials. Inspection tests form the basis of acceptance of production articles.
 - a. Quality verification tests.
 - b. Individual acceptance tests.

- c. Receiving inspection tests.
 - d. Calibration tests.
 - e. Production inspection tests.
5. Inspection Record - Recorded data concerning the results of the inspection with appropriate identifying information as to the characteristic or class of characteristics inspected.

SPECIFICATIONS

The manufacturing industry operates to various specifications while producing their products. These specifications are essential to ensure the quality of the hardware produced, and therefore, the new employee must have an understanding of these requirements. For this reason, basic blueprint reading and specification preparation have been considered important enough for incorporation in high school curriculum.

Some of the basic methods of communicating specifications in manufacturing are:

Blueprints (drawings)	Test procedures
Operating procedures	Equipment operating procedures
Company policies	Instruction manuals
Test procedures	Shop planning

The entry level student would receive on-the-job training relative to interpretation and implementing the various specifications used in that place of employment. However, at entry level the student should at least be aware of the basic blueprint terminology. These are listed below as a reference to follow for the interested student:

1. Dimensions and Tolerances

Interpretation of limits
Datums
Tolerance of buildup

2. Position Tolerancing

Coordinate tolerancing
Polar coordinates
True position tolerancing
Symbols
Concentricity
Symmetry

3. Form Tolerancing

Straightness
Flatness
Cylindricity
Profile
Angularity
Parallelism
Perpendicularity
Runout

4. Surface Texture

MECHANICAL INSPECTION AND MEASUREMENT

Mechanical measurements used in manufacturing are based on the following elementary relationships. They are:

1. Precision - exactness, degree of exactitude.
2. Accuracy - desirability (relation between observed or true values).
3. Reliability - probability of achieving desired results.
4. Discrimination - the degree to which an instrument subdivides the unit length (smallest readable).

To delineate the differences between these measurement terms, a variety of mechanical tools are used. Some of the basic units are listed to acquaint the student with these tools.

1. The rule: A scale graduated in proportion to a unit of length.

Architects scale

Engineers scale

2. Scaled Instruments:

- a. Depth gauge: measures holes, grooves, recesses. Combination squares; a blade and a square head (right-angle reference).
- b. Protractor head: for checking angles.
- c. Combination set: a combination square with a protractor and center heads.
- d. Calipers: instruments that physically duplicate the separation between the reference point and measured point of any dimension within this range, using:

Dividers - for line measurement.

Outside calipers - for end measurement.

Inside calipers - for end measurement.

Hermaphrodite - for line to end measurement.

- e. Surface Gauge: to transfer height measurements from part to standard.
- f. Micrometers: instruments that achieve higher amplification by the use of screw threads.

3. Gauge Blocks: End standards that combine arithmetically to form length combinations (the basic tool of precision measurement).
4. Optical Gauging: Gauging by sight rather than feel or pressure, using:

Optical comparator	X-Ray television systems
Tool makers microscope	Electron microscopes
5. Limit Gauges: Tools designed to measure a single dimension only.

a. Plug gauges	e. Feeler gauges
b. Ring gauges	f. Radius gauges
c. Snap gauges	g. Fillet gauges
d. Taper gauges	h. Flush pin gauges
6. Screw Thread Gauges: For screw thread measurement tolerances.
7. Torque Wrenches: Used to measure correct amount of pressure in the tightening of a nut.
8. Surface Plates: Serve as horizontal reference planes of sufficient strength and rigidity that measurement operations may be supported on it. Also used as grinding tables, planning tables and lathe ways.
9. Surface Roughness Scales: Used for evaluating roughness by sight or fingertip by using a scale with samples of comparable patterns.
10. Protractors, Squares, Levels, Clinometers: Used to measure angles.

ELECTRICAL TEST AND MEASUREMENT

Electrical measurement is one of the major measurement categories of concern to inspection and quality control. The student should be aware of this category of measurement and the basic instruments used by inspectors.

1. Resistance measurement: (typical equipment used)

a. Ohmmeter	d. Kelvin
b. Voltmeter - Ammeter	e. Megohmmeter
c. Wheatstone	

2. Current measurement:

- a. Galvanometer: For small currents in bridge circuits, potentiometers, and other measuring equipment.
- b. Ammeter (Shunts): For larger current measurements.

3. Voltage measurement:

- a. Voltmeter
- b. Electrodynamometer: Uses an air-core electromagnet in lieu of a permanent magnet.

4. Power measurement:

- a. Wattmeter: Measures electric power by employing two elements, one current operated and one voltage-operated.

5. Multiple measurement:

- a. Oscilloscope: Permits determination of current, voltage, and frequency by visual graphical relationships.

6. Capacitance and inductance measurement:

- | | |
|--------------------|----------------------------------|
| a. Schering Bridge | e. Resonance Bridge |
| b. Maxwell Bridge | f. Capacitance Comparison Bridge |
| c. Hay Bridge | g. Inductance Comparison Bridge |
| d. Owen Bridge | |

MEASUREMENT OF PHYSICAL AND CHEMICAL PROPERTIES

The measurement of special properties of materials, parts, and liquid is often required in manufacturing. Chemical solutions must be tested for the correct mixture. Water must be tested for purity. The weight of parts and products is also important, since many products are priced by the pound or gram. Most physical and chemical properties are too complex to measure by simple experiments. The following are only examples of the kind of measurements required.

PHYSICAL MEASUREMENTS

1. There are two basic systems of weights and measurements used.

British System

- a. The units of weight commonly used in the United States and other English speaking nations were derived from British units in colonial days.
- b. The basic units of weight are:

Ounces (oz.) Pounds (lb.) Tons

Metric System

- a. The metric system is ordinarily used for scientific measurement throughout the world and for commercial purposes in most nations.
- b. The basic units of weight are:

Grams (g) Kilograms (kg.)

2. The weights or objects are determined by two basic types of balances.
 - a. The equal arm balance: This type of balance is by far the most accurate and different variations are found in all laboratories. This type of balance uses the lever principle.
 - b. Spring balances: These types of balances use a spring mechanism which is compressed when a weight is placed upon them. A direct reading of the compression of the spring records the weight of an object. Since springs lose their elasticity over a period of time, these types of balances are not very accurate.

CHEMICAL MEASUREMENTS

1. Qualitative measurement or analysis is used to test for the presence of a certain substance in a sample of material or liquid. They are usually observed by one or more of the senses--color, taste, odor and touch.

2. pH measurement: The pH of water is a measurement which determines whether water is acidic, basic (alkaline) or neutral. This is of extreme importance to the sanitary engineer in terms of water softening, proper bacteria action on sewage, corrosive action of water and proper appearance and taste. Depending upon the environment, natural waters can become basic or acidic. Listed below are some common bases and acids found in the home.
 - a. Bases - Basic substances have a bitter taste, feel slippery to the touch and turn red litmus paper blue. Some common bases are: ammonia, bleach, baking soda, and lye.
 - b. Acids - Acidic substances have a sour taste and turn blue litmus paper red. Some common acids are: boric acid, lemon juice (citric acid), and vinegar (acetic acid).
3. Flame test of elements: Some chemicals, when placed in the flame of a burner will give off a color that is characteristic of that element. Some examples of this chemical reaction are as follows:

<u>Substance</u>	<u>Color</u>	<u>Color Due to</u>
NaCl Sodium Chloride (table salt)	yellow	Sodium
CuNO ₃ Copper Nitrate	blue-green	Copper
CuCl Copper Chloride	blue-green	Copper
CaCl ₂ Calcium Chloride	red	Calcium
KCl Potassium Chloride	violet	Potassium
KNO ₃ Potassium Nitrate	violet	Potassium

4. Spectral Analysis: A spectroscope is an optical instrument which breaks down the light entering it into separate frequencies by use of a prism or a diffraction grating.
5. Quantitative Analysis

Quantitative analysis is the determination of the presence of a substance in a sample of matter by weight or volume. Quite often the chemistry and mathematics involved in solving quantitative problems require a complete course in chemistry and a good knowledge of mathematics. There are, however, efficient methods employed using standard solutions which make this task simpler. As indicated before, color indicators will determine the presence of a certain substance in a sample of matter.

However, if a known amount of the indicator is added to a known volume of the sample, a direct reading of the intensity of the color will indicate the amount of substance present in the sample.

- a. Determination of chlorine quantity in a swimming pool.
- b. Determination of the pH value of water.

These tests are but two of many color indicator tests that can be done to determine the quality of any substance in a sample of solution. Modern laboratories will have in stock these standard solutions, which enables the laboratory technician to efficiently and accurately determine the amount of unknown in any sample solution.

Unit 7
THE QUALITY CONTROL CAREER FIELD

OBJECTIVES

1. The students will acquire a knowledge of the career field and major hierarchical characteristics.
2. The students will be able to discern hierarchy level in terms of
 - a. authority
 - b. responsibility
 - c. tools and equipments used
 - d. working environment
 - e. preparation profiles
3. The students will be made aware of the applicability of career field knowledge, skills and attitudes across all categories of the manufacturing enterprise.

TEACHING CONTENT

1. The instructor should discuss the content/function of the hierarchical career field.
2. The instructor should relate division-of-labor to inferred responsibility and authority levels.
3. The instructor should identify occupation and job tools, equipment and work script.
4. The instructor should identify work environmental information and preparation profiles for each major occupational category.
5. The instructor should show how generic knowledge, skills and attitudes of this career field apply across all manufacturing enterprise categories.

LEARNING RESOURCES

1. Standard Reference.
2. Quality Control Handbook; J. M. Juran, McGraw-Hill, New York, 1962.

EVALUATION

1. The instructor can utilize self-made tests.
2. The instructor can have the students display their understanding of the career field embodiment by having them plot selected knowledge and skills utilization in job profiles across some or all of manufacturing enterprise.

Unit 8
EDUCATION, TRAINING AND PROFESSIONAL DEVELOPMENT IN
QUALITY CONTROL

OBJECTIVES

1. The students will be able to distinguish between training, education and development.
2. The students will be able to relate training and education to career profiles and career ladders.
3. The students will be able to generate a future work-education plan for pursuit of careers in the quality control field.

TEACHING CONTENT

1. The instructor should define
 - a. training
 - b. education
 - c. profession/professional
 - d. development
2. The instructor should discuss and give examples of a career ladder related to education and experience within this career field.
3. The instructor should discuss the advantages of having the career field being "professional."
4. The instructor should discuss how training and education are utilized in maintenance and up-dating of skills and knowledge within this career field.
5. The instructor should discuss the benefits and trade-offs of early job entry vs. later job entry for selected occupations.
6. The instructor should discuss what the future seems to hold for people-workers in this field and how training, education and development might be viewed (i.e., the necessity for continuing education).

LEARNING RESOURCES

See selected information resources appended.

EVALUATION

1. The instructor can utilize self-made tests.
2. The instructor can assess and evaluate student made career profiles and ladders.

EDUCATION, TRAINING, AND PROFESSIONAL DEVELOPMENT IN QUALITY CONTROL

There are many opportunities and challenges in the field of manufacturing and quality control for the graduating high school student. Since the proper performance of all manufactured products depends on quality, the modern quality professional should be aware of the opportunities that enhance personal, company, and community growth and development.

The quality control field provides the following employment opportunities to the inquiring student:

Inspection	Reliability Engineering
Technical Development	Quality or Reliability
Quality Engineering	Management

High school student preparatory requirements that are considered basic for entry into the manufacturing industry are first presented and then followed with an approach to continued professional development.

HIGH SCHOOL PREPARATORY CURRICULUM

For the high school student to be prepared to enter the world of work in the quality control field, basic educational development is necessary. The following areas of study are recommended to the student interested in this field:

<u>Prerequisites</u>		<u>Concentrations</u>
Basic Mathematics	Human Relations	Electronics in Q.C.
Algebra	Quality Control Concepts	Nondestructive Testing
Trigonometry	Mechanical Measurements	Process Control
Geometry	Blueprint Reading	Metallurgy
Drafting	Statistics	Reliability Concepts
	Quality Reports/Data	Quality Costs
	Specification Preparation	

ON-THE-JOB TRAINING

On-the-job training is an accepted training method for inexperienced quality control employees. The amount of training necessary will depend on the industry and the complexity of the product being manufactured. Since the majority of companies do not have formal training programs, they rely on high schools to prepare students in basic educational needs. Specific skills are then learned by the new employees on an "as-required" basis.

Many of the skills are specialized and require a long training period and even certification in some situations. It is, therefore, necessary for the student to learn as many of the prerequisites as possible before entering the world-of-work in the manufacturing industry.

APPRENTICESHIPS

Certain manufacturing companies have apprenticeship programs in the field of quality control. These opportunities are very limited and do require a minimum of four years training and education. It does provide the company with a well trained employee but it is expensive to monitor and coordinate.

A high school diploma is required and a good background in science, mathematics, and shop practices is desirable for all trades. The apprentice then may earn up to forty (40) units of college credit for on-the-job training and related technical instruction. Then with an additional twenty (20) units of college credit, the student may qualify for an Associate of Science Degree in junior or community college where this program is available.

COLLEGE TRAINING

To have the student appreciate the educational opportunities that are available in American colleges and universities, the following is a list of certificates and degrees offered in the field of quality control:

<u>Certificate or Degree</u>	<u>Approximate Credit Requirements</u>
Certificate of Proficiency	27 Semester Units
Associate Degree	60 Semester Units
Bachelors Degree	124 Semester Units
Master's Degree	154 Semester Units

Many colleges in this country now have some type of quality control course offerings available to the student seeking continued education. An example of a career ladder available to a student in the quality control profession is illustrated in the following matrix entitled, "Educational Ladder for Quality Control," (See Figure 1, page 72).

PROFESSIONAL CERTIFICATES

The American Society for Quality Control is the major professional society related to the field of quality control. As with professional organizations, this society offers membership at various levels of a career in quality control. There is a student membership available for the high school student at a very nominal cost.

Of major significance, however, the quality control Society recognizes professionalism through the media of certification. The inspector that is aspiring for a career in this profession may prepare to become a Certified Quality Technician. Currently, there are several specific options that are available in this certification area. They are:

Chemical	Mechanical Inspection
Food and Allied Industries	Nondestructive Testing
Electronics Inspection	Inspection (Proposed)
Electronics Technician	Nuclear Power (Proposed)

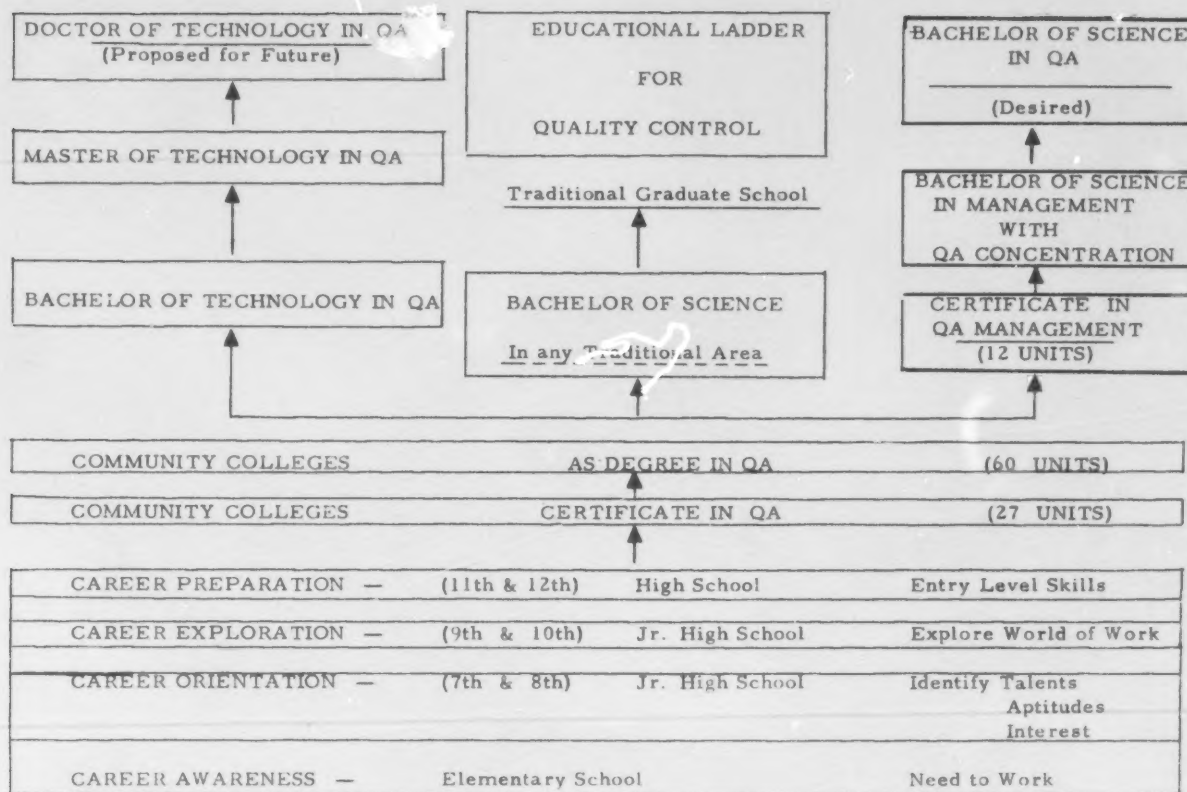
Certification is recognition by professional peers to an individual who, "in support of and under the direction of professional engineers, certified quality or reliability engineers, quality managers or scientists can carry out in a responsible manner, proven quality techniques or those techniques prescribed by engineers."

OCCUPATIONAL PREPARATION

This section of the Guide contains program guidelines for initiating specific subject matter courses for acquisition of "hard skills" in the program areas of:

1. Blueprint Reading
2. Statistics in Quality Control
3. Mechanical Measurement
4. Electrical Measurement
5. Chemical Measurement

Figure 1



Concurrently with this segment of course instruction, this Guide should be used with the Student Manual. The Student Manual contains greater detailed information about each of the subject matter areas than does the Instructor's Guide.

Also, at this point in program operation, the instructor may want to investigate the possibilities of coordinating this course material with other departments in the school system, or, utilize the industry/labor resource personnel, within the school or in their plant(s).

It would be very advantageous for students if the industrial personnel would acknowledge this request and help in the operation of this course section. Student awareness, orientation and exploration would be greatly enhanced by such a process. Much related and peripheral information could be gained and assembled by the student, relative to the overall program purpose.

The cost factors of operating this program will become evident in this section. The tooling and equipment needed for demonstration is expensive and, may be exotic and unique to a given industry. It would seem that any help obtained with this interrelationship would greatly enhance the program in terms of student interests and skills acquisition.

Unit 1 BLUEPRINT READING

PURPOSE

The purpose of this unit is to provide students with a basic understanding of why and how various engineering, production, inspection and related drawings, commonly called blueprints, are used in the manufacturing process. Also, by using an overview with actual blueprint examples, it will provide the students with basic skills related to identifying, reading, interpreting and translating the meaning of the blueprints.

INTRODUCTION

The Blueprint Reading topic should be discussed from a historical viewpoint. Except in rare cases, blueprints (i.e., white lined forms, dimensions, notes and table of materials) are not used, literally. Today, the proper term would be whiteprint, since the form and lines are black on a white background. In most instances, this is what is called a drawing and commonly referred to by many as a blueprint. (Now a generic name carried over from the processes of making a blueprint.) Generally, the term most encountered will be "an engineering drawing," or "an inspection drawing."

Before any engineering drawing is made of any system, component or part, there must be reason and purpose, and this is usually the customer, be it a need, want or desire. Normally, this is expressed in the form of a request, formal or informal. In the formal sense, the customer knows what is wanted and has a written specification. The specification may be very exact (tight) or be non-specific in certain areas (loose) as in choice of materials or tolerances.

Usually a tight specification is in the format of "Request for Quote." This format details time and other resources needed in making the items, and permits quite exact cost and time bids to be made on producing the product. But, conversely, a loose specification is usually in the format of "Request for Proposal." This format permits wider variations to the making of the product and usually means the manufacturing enterprise will have greater freedom in design of the product.

Regardless which of the above formats are utilized, either to secure work or to offer work to another enterprise, blueprints are the main communication media that relates to the actual production of the item.

The conversion of a specification into a drawing is quite involved. The operational procedures, greatly simplified, are:

1. Formation of a specification or the written specification, typically contains:

- Envelope (size limitations).
- Critical or full dimensions and tolerances.
- Performance parameters.
- Test parameters and conditions.
- Related specifications and drawings.
- Delivery schedules and quantities.
- Materials specifications.
- Special tooling references.
- Standard notes (flatness, surface finish, etc.).
- Special notes (special threads or finishes).
- Special test parameters (life testing, destructive testing).
- Special reclamation information (precious or scarce materials related).
- Standards parts lists.

The manufacturing enterprise personnel responsible in this segment of the beginning of a drawing are:

- Management Function (both corporate/business management and technical).
- President/Vice President.
- Engineering Management.
- Production Management.
- Quality Control Management.
- Industrial Engineering Management.
- Factory Management and Supervision.

These personnel are either forming the specifications based on interpretation from marketing and sales, plus engineering information or data; or, interpreting the received notification (specification--with or without accompanying drawings) in terms of considering a bid on it.

Support Function:

- Service Personnel
- Finance, determining costs/profits
- Legal, contract matters
- Marketing/Sales, market surveys and sales program
- Data Processing, capability of present programs
- Public Relations, program design for advertising.

These personnel are either interpreting the specification received in each of their areas of interest; or supplying the information in order to make up a specification for sending out to another manufacturer.

Engineering Function:

Research and Development, determining capability
Tooling, determining tools/equipment
Industrial, determining manufacturing system capabilities
Plant, determining capabilities
Production, determining processes
Quality Control, determining methods, instrumentation and equipments

These personnel supply information from previous products, methods/techniques and capabilities when interpreting the specification; or, supply product limitations when making up a specification.

2. Formation of the Drawing

The engineering function is where the actual drawing is made; the hierarchy is as follows:

Interpretation/formation of the specification	Research/development
Translation of specification into drawings	Design engineering
Supporting functions supplied by research and development engineering	
Support functions supplied by tool engineering	Designers
Production/process engineering	Draftsmen
Quality control engineering	Checkers
	Parts specialists
	Change order and control personnel
	Drawings reproduction and records personnel

When the drawings are printed, it is usual to have a meeting of all personnel concerned. This includes management, support, engineering and factory representatives. This meeting is called a design review meeting. At this meeting, specification compliance is

discussed and agreed upon or not. At this meeting, changes are made and another review scheduled. This continues until drawings are acceptable.

Usually, the drawings being discussed are called engineering drawings or design drawings. If the products being manufactured, or put out for bids, are complex, the design drawings are not dimensioned, toleranced or noted in a format suitable for use in production or inspection activities. The relationship could be:

	-----Design Drawings-----	
	-----Production Drawings---	Directly
Indirectly -----	Tooling Drawings-----	Related
Related -----	Inspection Drawings---	

Factory Function Personnel:

Materials	input derived from each unit
Parts	and fed into the drawings
Assembly -	through middle and upper
Inspection	factory management, supervision
Reclamation	and union representatives.
Distribution	

These personnel do not participate directly in formation of drawings. However, these personnel use the drawings on a day-to-day basis. The drawings are the actual basis for the activities and operations they perform. The drawings, to some degree, describe their jobs or tasks.

As noted, drawings are vital to any manufacturing enterprise. They are the language of operation. Interpretation of the sketched symbols which may represent a piece of hardware or a product is critical to the capability of the enterprise to stay in business and to conduct an acceptable and proper manufacturing business.

Drawings are usually dimensioned in five basic sizes as listed:

1. is the smallest, usually a standard page in size. This size is used for depicting small parts, small tools and small products.
2. is approximately double the 1 size in the length dimension. This size is used for larger parts, tools, products and sometimes written specifications.

3. size is approximately 18 x 24 and used for larger purposes such as assemblies depiction.
4. is approximately 24 x 36 and used for complicated products, parts, or assemblies.
5. is approximately 36 inches wide and non-specified in length. This is used, usually, for complicated, complex, life-size or near-scaled systems or larger assemblies (textile machinery frames - 50 foot lengths, 3-5 lengths per section in the mill).

Quality control, inspection and test must have input to specification and drawing formation during design and at the design review meeting. When the specification drawing is made, quality control personnel assures that it can be measured, instrumented and related to the specification parameters. During manufacture of the product, quality control personnel maintain the desired specifications.

LEARNING RESOURCES (BLUEPRINT)

Job Entry Training Program: Instructor's Guide; National Machine Tool Builders Association; Washington, D.C.

National Apprenticeship and Training Standards; National Machine Tool Builders Association; Washington, D.C.

Blueprint Reading for Machines Parts Inspectors; General Dynamics Corporation, San Diego, California.

Blueprint Reading; Program Planning Guide; Gregg-McGraw-Hill, Inc., New York, Instructional Unit \$17.50; 30/45 hours in length.

DIMENSIONS AND TOLERANCES

OBJECTIVES

The student will be able to:

1. Understand the need for blueprint reading in industry.
2. Know how to read dimensions on the blueprint.
3. Understand how to calculate tolerances when necessary.
4. Be able to interpret tolerances and set limits of the appropriate dimensions.

5. Know what major lines describe an object.
6. Calculate tolerance buildup and apply it to the drawing interpretation.

TEACHING CONTENT

1. Discuss the need for blueprints in the manufacturing industry and how they are used to communicate compliance to management and the customer.
2. Demonstrate by using examples of blueprints and review the following with the students:

- Symbols
- Identification data
- Tolerance descriptions
- Reference specifications and material callout
- Primary reference lines and reference planes
- Individual tolerances for specific dimensions

EVALUATION

The instructor should give students sample drawings and ask them to answer a series of questions related to the information on the drawing. The instructor may wish to use any of several existing practical exercises contained in training manuals or may wish to generate these requirements on a test. A factual working drawing is suggested with omission for the student to complete. Perhaps a simple drawing may be required to produce to assess student's knowledge of the lesson content.

POSITIONAL TOLERANCING, COORDINATE TOLERANCING, AND POLAR COORDINATES

OBJECTIVES

The student will be able to:

1. Recognize what positional tolerancing entails.
2. Identify coordinate tolerances and polar coordinates.
3. Distinguish true position tolerancing from other forms of tolerancing.
4. Interpret the basic drawing symbols.
5. Have a good knowledge of drawing features such as concentricity and symmetry.

TEACHING CONTENT

1. Illustrate the various tolerancing techniques and symbols by using a chalk board or blueprint handouts.
2. Require students to prepare a simple drawing and have them illustrate the basic position tolerances. The following items should be stressed:
 - a. Coordinate tolerances
 - b. Polar coordinates
 - c. True positions
 - d. Concentricity
 - e. Symmetry

EVALUATION

1. Provide the students with an unidentified list of symbols and have them complete the various tolerancing identifications.
2. Require the students to describe the various tolerancing methods on an unmarked drawing.
3. Have the students demonstrate their drawing tolerancing knowledge by using the chalk board or exam drawing and having each student enter at least one of the basic tolerances on a drawing outline.
4. Provide simple objects to the students and have them prepare basic sketches with the required positional tolerances.

FORM TOLERANCING

OBJECTIVE

The student will be able to:

1. Distinguish among the different form tolerances.
2. Identify the various form tolerances.
3. Interpret the drawing references that relate to form tolerances.
4. Sketch the different forms when given example tolerances.
5. Understand the significance of form tolerancing and be sensitive to drawing misinterpretation.

TEACHING CONTENT

1. Illustrate the various form tolerancing methods by using the chalk board.
2. Distribute example forms that might depict the differences between the following forms:

Straightness
Flatness
Roundness
Cylindricity
Profile

Angularity
Parallelism
Perpendicularity
Runout

3. Provide the students with drawing examples that illustrate the form tolerancing methods.

EVALUATION

1. Have the students describe the different form tolerances on the chalk board or on unmarked drawings.
2. Require the learners to prepare a simple drawing and specifically identify the form tolerances illustrated in the lesson material.
3. Use quizzes with questions related to form tolerancing and have the students provide missing tolerances.

SURFACE TEXTURE

OBJECTIVE

The learning of surface texture terminology and techniques will require the following student abilities:

1. To understand what surface roughness is and how it applies to manufacturing.
2. To know the symbols used to describe roughness features.
3. To distinguish from smoothness.
4. To be able to perform simple roughness arithmetical calculations.
5. To be able to perform the basic methods of roughness measurement.

TEACHING CONTENT

1. Present a description of surface roughness and the symbols used to identify them.
2. Distribute various types of hardware that have obvious differences in surface texture.
3. Demonstrate surface roughness by passing "feeler gauges" among the students for their actual touch and feel of the different roughness intensities.
4. Visit a manufacturing plant that uses various methods of surface measurement and have a representative describe these methods.

EVALUATION

1. Have the students feel unmarked samples of surface texture and describe the value of the touch.
2. Quiz the students in calculating simple surface roughness calculations.
3. Require the learners to demonstrate their ability to distinguish the differences in surface texture departures as part of a laboratory examination.

Unit 2 STATISTICS IN QUALITY CONTROL

PURPOSE

The purpose of this unit is to familiarize students with the bases of statistics usage in quality control, inspection and test activities. Also, this unit will provide students with skills in the methods and techniques of statistical quality control and extension into operational problem solving.

INTRODUCTION

Statistics is a term with varied interpretation. Statistics is the terminology of a special section or segment of the field of mathematics. This includes descriptive statistics, inferential statistics and the special sub-field of mathematical statistics.

Statistic is a term in which meaning is usually misconstrued. A statistic is a measure of something, such as the average age of death for men is 65 years. The reason that it is a statistic is that it is very representative of the entire male population in the United States and has been "measured" over a long time. The figuring out that the average age of students in an 11th grade class in Rockland, Maine, is 17 years of age is not a statistic, but is a parameter or an estimate. It is not reliable when the attempt is made to use the 17 years of age estimate as a basis for saying that the average age of 11th year classes in schools in the United States (anywhere) is 17 years. Before it could become a statistic, the entire population would have to be considered. Too often the word statistic is erroneously used in order to convey information importance. This is especially true in advertising, or general conversation such as: 9 of 10 people prefer X-Brand cigarettes. Logically, you know this is erroneous because the 25 remaining cigarette companies are not selling cigarettes to only one person of the 10 who smoke. The statistic implied is 90 percent of the smoking public use X-Brand. What might be very true, likewise, is that there are only 10 people who smoke and were surveyed, in the plant after having been on tour, and were given a pack of cigarettes. They smoked them and for some (yet unknown) reason, 9 of those 10 people preferred X-Brand cigarettes. Many times, advertising, various agencies and institutions give out statistical information, but the numbers are not statistics in the true sense.

Statistics is in the field of probability. Recognition of this is shown in the various means and methods for correcting the values of data and estimate figures. Corrections are especially easy in descriptive statistics; especially difficult in inferential statistics.

Statistics is the backbone of quality control, inspection and test activities. Data acquisition, reduction and analysis by statistical means and methodology is the main element of the active control sub-function personnel responsible in all three activities.

Along with this knowledge and skill dimension goes the most difficult attitudinal component, clinical observation, reporting and analysis. This attitudinal component must manifest honesty and accuracy. It is important that these attributes of the quality control, inspection and test field be brought to the attention of the students. These dimensions are very important as decisions are going to be made based on statistical analysis, such as: Will the life-support systems work in the space capsule for the length of the mission? Will the car-braking system work for a given mileage, and at the exact time I need them, within that mileage total?

Often, that which is termed "no-good," "inferior" or "poor products" is a direct result of erroneous data acquisition and analysis resulting in shipping out products (as being acceptable to a specification) based on wrong or misinterpreted information in both the on-line operating departments as well as the quality control section.

In the quality control field, the worker is very important and has great responsibility to both the manufacturer and consumer, sometimes, a conflicting situation.

LEARNING RESOURCES (QUALITY CONTROL STATISTICS)

Fun With Figures; F. Maroney, Penguin Pocket Books, Baltimore, Maryland.

Mathematics for the Millions; L. Hogben; Bantam Books, New York.

The above are pocket books, and well worth having for general mathematical and statistical purposes. Students contemplating career fields utilizing statistical analysis in some aspect should find these books to be both readable/understandable and enjoyable.

For the purposes of teaching statistics at this level, a suggested way would be to contact the American Society for Quality Control and obtain their industrial statistics courses. These follow programmed instruction methodology and provide a rather complete notebook for the students. Many industries have similar type courses available.

INTRODUCTION TO STATISTICS

OBJECTIVE

The student will be familiar with statistical quality control and the need of statistics in manufacturing. The following additional objectives are:

1. The student will understand attributes and their use in industry.
2. The student will have an awareness of the variations that exist in production and the methods of illustrating the variations.

TEACHING CONTENT

1. Discuss the need for statistics in quality control and stress the use of these mathematical techniques in manufacturing.
2. Demonstrate the conversion of variable data to attribute data.
3. Illustrate the use of attribute inspection techniques as alternative to variable techniques.
4. Describe the use of attribute techniques where variable techniques are not practical.

EVALUATION

This material can be tested with a quiz. However, a visit to a manufacturing plant where statistics are used would be very appropriate for illustration purposes.

VARIATIONS AND ANALYSIS OF DATA

OBJECTIVE

The student will be able to demonstrate an ability to tabulate visual data and to evaluate these data subjectively in accordance with statistical theory. Additionally, the student will:

1. Develop a normal distribution curve.
2. Calculate the average and descriptively present the data.

3. Describe the range of data and determine the value.
4. Tabulate data collected and demonstrate the ability to plot distribution curves.
5. Calculate the standard deviation of the data collected and distributed.

EVALUATION

The instructor should assign a series of data for the student to analyze, tabulate, distribute, and develop into distribution curves.

Student understanding of data-visual-subjective should be tested by examination and verbal discussions.

SAMPLING FOR QUALITY

OBJECTIVE

1. The student will understand the need for sampling in the manufacturing industry.
2. The student will determine when sampling is required.
3. The student will have the ability to read the sampling tables and determine how many items should be inspected for adequate control.

TEACHING CONTENT

1. Present the causes of variation to introduce the need for sampling.
2. Review the frequency distribution lesson to refresh the student's memory of terminology.
3. Describe the basic definitions of sampling and relate them to practical applications.
4. Demonstrate sampling by random selection of pre-described experiments.
5. Illustrate sampling techniques by using a common sampling table. (Note: Mil-STD-105D is available from most industrial plants and the United States Office of Education.)

EVALUATION

Have the students demonstrate their knowledge of sampling by assigning practical exercises. Have them select a sample size by reviewing the tables provided them.

Perhaps a quiz would be appropriate to ensure student knowledge of sampling theories and benefits to the manufacturing industry.

Unit 3 MECHANICAL MEASUREMENT

PURPOSE

The purpose of this unit is to provide the student with an opportunity to identify typical measuring instruments and to learn associated terminology about them and in their usage. Also, the student will be able to acquire skills used in the technique and methodology of measurement.

INTRODUCTION

Measurement is basic to all types of work whether it is formal job-connected or informal as fixing appliances or putting in patios around the home. The main factors of measurement are:

1. To what degree is accuracy required?
2. What instrument should be utilized?
3. How the measurement is read and transferred?
4. What is to be done with the "reading?"

Nearly all entry-level jobs within manufacturing enterprise have a measurement component, be it weight, distance or volume. Instruments are used and/or referenced for job-task purposes.

The simplest measurement is linear. This means the instrument used is easy to obtain, understand and utilize. Mechanical measurement is very difficult in the linear field when high accuracy is needed. It is not possible in a short course of instruction to fully equip students with the capabilities and attitudes necessary for reliable and accurate measurement.

This unit should be coordinated with on-going secondary school courses in geometry, trigonometry, analytical geometry and general drafting courses. Practical experience could be gained in any number of on-going industrial arts or vocational courses.

Similarly, by using examples found in the home or hobby domain, measurement can be taught. Girls making dresses measure; boys working on cars measure; home economics students measure, as examples.

LEARNING RESOURCES (MECHANICAL MEASUREMENT)

Hand Measuring Devices; A programmed instruction manual; General Dynamics, San Diego, California, 1974.

Apprenticeship Training Courses; Tool and Die Makers, National Tool, Die and Precision Machining Association; Washington, D.C.

In general, because of the cost of buying, keeping or using these instruments in a school system, it is recommended that the industrial education and vocational program personnel be contacted for lecture, demonstration and related information in the conduct of this unit.

SCALED INSTRUMENTS AND ACCESSORIES

OBJECTIVES

1. The learners will demonstrate a basic understanding of linear measurement to include the concept of measuring the distance between points.
2. The learners will have a basic knowledge of the evaluation of present day systems and units of linear distance.
3. The learner will have a basic awareness of variability in measurement as a source of error.
4. Know the units of linear scales, and precision scales.
5. Know what a ruler, yard stick, meter stick are.
6. Know how to measure linear distance using both English and metric scales.

INTRODUCTION

Prior to initiating the following activities the instructor should arrange to have appropriate resources that deal with the factual/conceptual content of this lesson. A listing of resource materials can be found in the resource listing which accompanies this guide. Since experience based activities provide the best potential for effective transfer of learning, the instructor may want to arrange for demonstration of the concept of variability as a source of error.

When initiating the activities, the instructor should attempt to ascertain what facts and concepts are already familiar to the learners. A short review may be all that is necessary for the lesson content, but, primary attention should focus on the topic of tolerance since knowledge of tolerances is an important aspect of inspection and quality control jobs.

TEACHING CONTENT

1. The instructor should conduct a review session covering the various linear scales including relationships, history and evolution of standards. An interesting method of introduction might be a discussion about the future conversion in America to the metric system.
2. The instructor should provide learners with an opportunity to discover for themselves that variability in measurement is common. Have them measure an item, report, and compare findings. A discussion should reinforce the idea that variability in measurement becomes one of the potential sources of error.

EVALUATION

1. The students must be able to utilize the basic scaled instruments and demonstrate the knowledge by laboratory or classroom verification.
2. The instructor should use whatever procedure that is most feasible to assess student knowledge of factual data relating to graduation in scaled measurement. The instructor should also be satisfied that students have gained a basic awareness of the concept and application of tolerance in scaled measurement.

VERNIER INSTRUMENTS

OBJECTIVE

The student will demonstrate elementary skills in the use of vernier measuring tools.

INTRODUCTION

The vernier instrument is essentially the first of the precision instruments. The vernier is a visual method of subdividing the smallest divisions on a scale to make still finer readings possible.

It was invented by Pierre Vernier, a French mathematician, in 1631. Joseph R. Brown used this principle in the vernier caliper in 1851. It was the first tool capable of measuring the thousandths of an inch to become available to the machinist.

TEACHING CONTENT

The students should be given direct assignments with various types of vernier instruments to gain skills in their use in external, internal, and depth dimensions.

The instructor should demonstrate the use of the instruments or present films that illustrate their uses in dynamic form.

EVALUATION

The students should be able to demonstrate and/or describe the use of vernier instruments and how they are applied in the manufacturing industry.

MICROMETERS

OBJECTIVE

The student should be able to demonstrate elementary skill in the use of the micrometer and to explain the principal on which its operation is based.

INTRODUCTION

The micrometer is one of the most frequently used measurement devices. Its design permits the user to perform accurate precision measurement. Given the importance of the micrometer as an instrument for measurement, learners should know how the instrument works, for what kinds of measurements it is used, and should be able to demonstrate the use of the micrometer. The instructor should have various materials available to facilitate demonstration and explanation, and actual use of a micrometer is essential to a thorough understanding.

TEACHING CONTENT

1. The instructor should demonstrate and describe the micrometer and discuss the capabilities of this instrument for use as a precision measurement. (A sectional view of a micrometer and other resource materials would be helpful for purposes of this activity and subsequent activities in this lesson.)
2. Explain the use of screw threads for measurement precision.
3. Explain the use of mechanical levers to amplify scale displacement and translate in terms of the screw as used for the micrometer.

4. The instructor should explain and demonstrate the use of the micrometer and the function and reading of its vernier scale. Learners should be permitted to practice using a micrometer until they can easily perform measurement tasks using the instrument.

EVALUATION

The instructor should insure that learners can describe the operation of a micrometer, the principle upon which it is based and that the learners can use a micrometer correctly.

LIMIT GAUGES

OBJECTIVE

The student will be able to demonstrate elementary skills in the use of limit gauges to perform accept/reject measurement.

INTRODUCTION

Limit gauges are standard items for inspection. Since many production items have tolerance limits, measurement must be such that both limits can be tested. Learners should be familiar with the various limit gauges and how they are used in determining whether an item is accepted or rejected.

TEACHING CONTENT

1. The instructor should describe the purpose of limit gauges and basic procedure employed in using such gauges.
2. The instructor should demonstrate snap gauges, ring gauges and plug gauges and how they are used to determine conformance to specifications. Learners should be allowed to practice using those gauges in either actual or simulated accept/reject measurement tasks.
3. The learners should also be given instruction with more complex gauges used to determine conformance to specifications. The instructor should supervise learners in the use of these gauges.

EVALUATION

The instructor can set up a sample of accept/reject measurement tasks and have learners go through the series, performing each task. A simple response check list can be filled in by each learner to determine if more instruction is necessary or if learners are ready for the next lesson.

THREAD GAUGES

OBJECTIVES

1. The student will be able to explain and/or demonstrate the use of special purpose gauges for measuring internal and external threads.
2. The student will be able to differentiate between conventional thread standards and metric thread describing the major differences.
3. The student will understand the concepts and applications of torque measurement and applications.

INTRODUCTION

Thread gauges are standard tools for many inspection/quality control tasks. Learners should have at least minimum competence in using these gauges and should be conversant in the basic terminology of thread measurement. Significance of proper force during screw applications should also be understood.

TEACHING CONTENT

1. The instructor should discuss briefly the measurement of threads and describe (with illustrations) the various classifications of threads.
2. The instructor should have thread gauges, taps and dies available in order to illustrate and demonstrate their use in measurement of internal and external threads.
3. The instructor should define the terms root, pitch, and lead as applied to thread specifications. The learners should be aware that these are fundamental terms related to measurement of threads.

EVALUATION

Assess students for basic skills in the use of thread and gauges for their elementary appreciation of common and metric thread standards. With classroom discussion, and through practical experiences, students should make sample measurements. Students should be able to report thread specifications in terms of root, pitch and lead, and review the applications of torque wrenches and applied concepts of proper force.

SURFACE PLATES/GAUGE BLOCKS

OBJECTIVE

To enable the student to demonstrate basic knowledge of the application of surface plates and gauge blocks in performing linear measurement and measurement of plane surfaces.

TEACHING CONTENT

1. Discuss the surface plate and its function in measurement.
2. Present and teach the concept and application of gauge blocks for precision and accuracy in measurement.
3. Use classroom demonstrations and student practice supplemented by lecture and supervision of student practice.

EVALUATION

As in previous lessons, the instructor should set up practical exercises which require the students to demonstrate their skills in using surface plates and gauge blocks.

OPTICAL AND ANGULAR MEASUREMENT

OBJECTIVE

The student will be able to understand the fundamentals of angles, and optical measurement as related to mechanical measurement.

INTRODUCTION

Skills in angular and optical measurement are important in the fields of inspection and quality control. Many products have angular dimensions which must be checked to insure that production is meeting acceptable standards. Students should be familiar with and know how these measurements are made.

TEACHING CONTENT

The instructor should have the necessary materials, apparatus, or plant visitations planned to supplement a presentation which includes:

1. Review angles and angular units of measure in degrees, minutes, and seconds.
2. Teach the use of a precision protractor to measure angles between surfaces or points of reference.
3. Demonstrate the use of fixed gauges to perform angular measurement.
4. Demonstrate the use of the optical measuring machines such as the comparator and toolmaker's microscope.

EVALUATION

The instructor should set up practical exercises requiring students to perform various angular measurements. Student knowledge and skill can be assessed directly, through such exercises or by review of observations made during plant visitations where optical and angular equipment is used.

Unit 4

ELECTRICAL MEASUREMENT

PURPOSE

The purpose of this unit is to acquaint the student with electrical instruments utilized for measurement and to enable the student to identify and select instruments used in performing typical electrical measurement. Also, the student will acquire skills and related knowledge concerned with terminology and operation of the electrical measurement instruments.

INTRODUCTION

Electrical measurement is, by nature of the instrument, more accurate. Measurements can be made improperly due to hooking-it-up wrong or reading a high or low, and not a median value. Generally, electrical instruments are quite sensitive to even minor impacts particularly dropping them. Calibration is a major area of concern with meters. Proper installation is critical for electrical instruments in order to protect the part, component or assembly being tested as well as the instrument and operator.

At the job-entry level, in-plant training will be necessary before the entry worker is allowed much latitude with the electrical instruments. Again, as in the previous units, the industrial education and vocational programs may provide aids in conducting this section.

Some "live-work" could be developed using the home or community as a basis for understanding electrical measurement. The Wattmeter, or electric meter on a home, can be utilized for measurement purposes. A car tune-up, with meters, could be watched/explained and cover many of the principles taught.

Related on-going courses can be coordinated with this lesson. These would be physics, chemistry, mathematics, selected industrial education and vocational courses.

LEARNING RESOURCES

An excellent basic reference is:

Electrical/Electronics Instrumentation; programmed instructional unit No. 50; Gregg-McGraw Hill, Inc., New York.

The industrial education or vocational education programs may have electrical test instruments useful for this purpose.

INTRODUCTION TO DIRECT CURRENT (DC)

OBJECTIVES

1. The learner will demonstrate a basic understanding of direct current and the symbol used in referring to direct current.
2. The learners will be able to calculate solutions to simple direct current circuit problem.
3. To be able to use simple meter scales and relate the readings to basic DC circuits.

INTRODUCTION

The teacher should be prepared to relate basic direct current use to the learners by demonstration and application of appropriate equipment. Perhaps a plant visit would aid the teacher in demonstrating practical applications of DC electricity. However, the primary source of learning experience in electrical measurement is hands-on experience.

TEACHING CONTENT

1. The teacher should review student experiences for instructional topics to introduce subject of DC.
2. The teacher should demonstrate the basic electrical equipment as an introduction to electricity. Use should be made of all possible direct current meters.
3. The teacher should provide supervised learning experiences. The students should be given practical exercises and equipment for hands-on utilization.

EVALUATION

1. The teacher may evaluate student theoretical knowledge by examination and quizzes.
2. Practical exercises should be utilized to evaluate student ability to perform electrical measurements.
3. A laboratory examination would be beneficial for determining learner skills development.

THE GALVANOMETER MOVEMENT

OBJECTIVE

1. The learner will understand the galvanometer both in theory and in practice.
2. The student will identify the basic parts of a galvanometer.
3. The learner will be able to read a galvanometer and relate the values to simple circuits.

INTRODUCTION

The galvanometer is a frequently used instrument for measuring electrical current by using a D'arsonval movement. Theories and the associated practical applications are important for basic student understanding.

TEACHING CONTENT

1. The instructor should demonstrate the D'arsonval movement by graphic presentation.
2. A disassembled galvanometer would be most helpful in depicting the actual movements of the meter.
3. Practical exercises should be assigned to learners for their experience in handling and reading circuits with a galvanometer.

EVALUATION

1. The teacher may use written examinations to have students identify parts of the galvanometer and explain the uses of the equipment.
2. Evaluation of student skills learned could be made by laboratory testing.

AMMETERS, VOLTMETERS, WATTMETERS, AND OHMMETERS

OBJECTIVES

1. The learner should know the basic differences of the meters used in this lesson.
2. The students will be able to read the meters for current, voltage, watt, and ohm values.

3. The learners will be able to explain the various applications of the ammeter, voltmeter, ohmmeter and wattmeter.

INTRODUCTION

The ammeter, voltmeter, and ohmmeter are the most used tools of the electrical inspector in the manufacturing industry. They are very basic and are generally required for use by the entry-level inspector. The wattmeter is used less but considered to be important as a basic tool. A typical use of the wattmeter can be found in the home because it measures the quantity of electrical power used in any period of time.

TEACHING CONTENT

1. The instructor should demonstrate and describe the ammeter, voltmeter, ohmmeter, and the wattmeter and explain their application to electrical circuits.
2. Films, slides, and pictures that are available should supplement teacher presentations. These could be used and displayed for ready learner reference.
3. The teacher should obtain and have the meters available for student use with practical exercises, under teacher supervision.

EVALUATION

1. The instructor should determine if learners can explain the operation of the ammeter, voltmeter, wattmeter, and ohmmeter.
2. Practical exercises should be used to evaluate an indication of student skills attainment.
3. Observation of students during laboratory experiments are beneficial in learner assessment.

THE OSCILLOSCOPE

OBJECTIVE

1. The student will understand the basic oscilloscope and its use in electrical measurement.
2. The learner will identify the basic patterns of current and voltage on the oscilloscope display screen.

INTRODUCTION

The oscilloscope is helpful in electrical circuit analyses by displaying electrical patterns visually on a screen grid. It provides the ability to evaluate variations rapidly and permits qualitative information about circuits.

TEACHING CONTENT

1. The instructor should demonstrate use of the oscilloscope for lesson purposes.
2. The teacher should describe the different electrical patterns displayed on the oscilloscope screen during circuit analysis.
3. With supervision, allow students to operate the oscilloscope on simple circuit set-ups. Provide them with written procedures to assure proper operation.

EVALUATION

1. The students should demonstrate their abilities by using the oscilloscope to display different voltage, current and frequency forms.
2. Written examinations may be used to supplement teacher evaluation of learners progress.

ALTERNATING CURRENT

OBJECTIVE

The student will demonstrate knowledge of the characteristics of alternating current and the effect of inductance and capacitance in AC circuits.

INTRODUCTION

Alternating current (AC) is the most common form of electricity used in the manufacturing industry. A working knowledge of alternating current is required for entry-level work in the industry.

TEACHING CONTENT

1. Describe the concept and form of alternating currents and AC voltages.

2. The teacher will explain the characteristics of capacitance and its effect on an AC circuit.
3. The teacher will explain the characteristics of inductance and its effect on an AC circuit.
4. The instructor should demonstrate the relationship of phase angle and frequency on an AC circuit.

NOTE: Use an oscilloscope to demonstrate the form of AC voltage and to illustrate the effect of changes in frequency upon circuit impedance. If possible, use a twin beam oscilloscope to display both current and voltage simultaneously. Let the students in turn operate the oscilloscope.

EVALUATION

The instructor should set up practical exercises in class. These exercises should be such that the student will be required to demonstrate his/her understanding and skill relative to the objective. (Whenever appropriate, lessons can be combined.)

INDUCTANCE AND CAPACITANCE

OBJECTIVE

The student will have the ability to define the function of frequency upon inductive and capacitive reactance and to describe the basic measurement procedure for capacitance and inductance.

INTRODUCTION

Inductance and capacitance are basic to alternating current measurements. Several forms of bridges are used in industry to perform the required electrical measurements.

TEACHING CONTENT

1. Present the mathematical computation of reactance for capacitors and inductors.
2. Introduce the balanced bridge for measurement of reactance and resistance AC networks.
3. Discuss the use of variable capacitors and inductors in balanced bridges.
4. Discuss the use of various bridges for precision measurement of capacitance and inductance.

NOTE: Use classroom lecture supplemented with oscilloscope demonstration. Let students set up and operate oscilloscopes.

EVALUATION

The instructor should set up practical exercises in class. These exercises should be such that the students will be required to demonstrate understanding and skill relative to the stated objective of the lesson. (Whenever appropriate, lessons can be combined.)

FREQUENCY

OBJECTIVE

The student will demonstrate the ability to describe several alternative measurements of frequency.

INTRODUCTION

Alternating current frequency is basic knowledge in electrical measurement. Frequency meters are varied relative to type and configuration.

TEACHING CONTENT

1. Demonstrate the use of oscilloscopes to measure frequency.
2. Explain the use of electrical resonance to measure frequency.
3. Illustrate or describe the vibrator to measure frequency.
4. Describe or illustrate a transducer type instrument using a frequency indicating instrument to obtain an audible signal for frequency matching.

NOTE: Use instruments as available in the classroom or arrange for a field trip to some local industrial laboratory.

EVALUATION

The instructor should set up practical exercises in class. These exercises should be such that the student will be required to demonstrate his/her understanding and skill relative to the objective. (Whenever appropriate, lessons can be combined.)

Unit 5 CHEMICAL MEASUREMENT

PURPOSE

The purpose of this unit is to enable the students to identify basic chemical measuring equipment used in the chemical industry as well as in general chemical measurement. The students will acquire selected skills and knowledges in the usage of simple equipment as well as learn terminology and related information.

INTRODUCTION

Basically, chemical testing and measurement is accomplished in the three listed areas:

1. An analytical laboratory;
2. In the manufacturing plant; and,
3. In the research or engineering department.

Chemical tests and measurements exist primarily for control purposes but with differences in each area.

The analytical laboratory is primarily engaged in:

1. Chemical testing of incoming materials or products.
2. Testing for chemical-process decisions.
3. Determining acceptability of the finished chemical product(s).

The manufacturing plant primarily engages in:

1. Increasing operational efficiency in chemical processing.
2. In-process control of chemical production and quality.

The research and/or engineering department is primarily engaged in:

1. Developing new methods and techniques in chemistry.
2. Designing new processes.
3. Designing new chemical test and measurement techniques.

The field of chemistry invariably works in concert with the field of physics. This means that chemical, electrical and mechanical measurement are used concurrently. This is accomplished dependent upon the properties and characteristics of the

items, products or materials. This can be seen when a magnetic material has to be utilized for an electric motor. The chemical properties of the steel must have certain shapes, sizes and hardness; and the overall characteristic of the metal must exactly meet some specification.

An overview of chemical control and measurement leads to consideration of the three areas previously discussed: analysis of the raw materials; sampling and analysis of manufacturing methods and procedures for the products; and, analysis of the finished product.

Chemical measurement is difficult to accomplish due to the relatively complex and expensive equipment involved. Job-entry, usually, does not include a requisite for specific skills in techniques, which may be obtained by in-plant training.

However, many related experiences and simple experiments can be available in order to teach this unit. Ecology programs are a good start. Water and air are quickly and inexpensively being tested/measured. Food processing plants would be pleased to conduct demonstrations. Women's cosmetic manufacturers will conduct courses in chemistry for their field. Bottling plants encourage visitations. The departments of agriculture, universities and 4-H Clubs will send kits and/or give lecture demonstrations in environmental and ecology areas.

As in the previous units, on-going courses in chemistry, physics, mathematics and selected portions of industrial and vocational education programs are interrelated. These provide an opportunity to begin investigating these areas for applicability of quality control and measurement.

LEARNING RESOURCES

A reasonably priced, easily used tailored course of instruction in chemical test and measurement with an emphasis on quality control is not readily available. As a starting point, a high school lab course book or collegiate freshman chemistry lab book would be useful, such as:

Quality Control Handbook; (Eds.) J. M. Juran; L. A. Seder; and F. M. Gryna; McGraw Hill, Inc., New York, 1962.

Many pamphlets, filmstrips and booklets are available from the Environmental Protection Agency, Washington, D.C.; state agencies; and universities, as well as from industry.

QUALITATIVE METHODS

OBJECTIVES

1. The student will be able to demonstrate a general understanding of basic qualitative chemical analysis tests in quality control such as Ph factor and presence or absence of certain chemicals or contaminants.
2. Be able to demonstrate a general awareness of error possibilities in qualitative chemical measurement and how to interpret those errors in terms of probable effects on the purpose of the chemical test as it relates to quality control applications.

INTRODUCTION

Many industrial, commercial, government and public utility or service situations demand the presence or absence of certain materials to assure product integrity and to provide consumer protection from safety and health hazards.

Qualitative chemical analysis methods are used to verify and control the presence or absence of chemical materials. The student must be made aware of the various methods of chemical analysis, as well as quality control application and its limitations. Equally important, the student must gain an appreciation of the qualitative methods of chemical analysis, the complexities of the methods, the effects of error in measurement, and the probabilities of error occurrences.

Ideally, the instructor should have the necessary statistical analysis training to discuss the ways errors occur and how one can evaluate data to establish the significance of errors and identify probable causes.

In addition, he should have the necessary apparatus and materials available to conduct practical demonstration of the chemical analysis methods and statistical analyses required to evaluate typical test results.

A minimum of five tests in one method performed by each student should be required to establish data for demonstration of error evaluation by statistical analyses.

Thorough preparation for classes in chemical measurement is mandatory to achieve desired results. Lesson outlines or plans are required so that students are given the needed information to learn and accomplish the various methods of measurement. Materials

and apparatus must be available and in good condition. Strict adherence to details must be emphasized and candid and objective reports must be required. Discipline procedures and safety rules for student protection and accurate results are necessary.

TEACHING CONTENT

1. Introduce the chemical measurement method.
2. Explain purpose of method and how it relates to quality control.
3. Discuss materials to be tested chemically.
4. Explain required apparatus, how used and safety rules.
5. Discuss procedure in detail and accuracies required.
6. Explain use of comparative standards.
7. Discuss errors and statistical analysis and probability rule applications.
8. Have students perform tests and make statistical analysis evaluation.
9. Review and critically analyze results.
10. Administer written examination on material covered.
11. Grade written examinations.
12. Discuss results with class.

EVALUATION

Written examination questions covering the material presented and practical demonstrations of the test methods should be administered. Five objective type questions covering the scientific principles and five subjective type questions covering suggested test applications are recommended for each method presented. Questions should cover student understanding of error causes and significance to the test purpose. Questions should also cover students understanding of quality control applications for each method.

QUANTITATIVE METHODS

OBJECTIVES

1. The student will be able to demonstrate a general understanding of the purpose of quantitative chemical analysis and the distinction between quantitative and qualitative analysis tests used in quality control.
2. The student will be able to demonstrate a general awareness of error possibilities in quantitative measurement and how to interpret these errors in terms of probable effects on the purpose of the test as it relates to quality control applications.

INTRODUCTION

Many industrial, commercial, government and public utility or service situations expect a certain amount of material present for product conformance to meet specifications and health or safety regulations. Degree or amount of materials present will be measured in quantities such as ounces or per gallon of dissolved chemical in water, grams per liter of a dissolved chemical in water, percent of each gas constituent in a mixed gas volume, percent of metallic elements in an alloy containing two or more metals and parts per million, such as undissolved minerals in drinking water.

The student must be made aware of the various ways to achieve quantitative measurements in chemical analysis, the complexities of the methods, the effects of error in measurement, and the probabilities of error occurrences.

Ideally, the instructor should have the necessary statistical analysis training to discuss the ways errors occur and how one can evaluate data to establish the significance of errors and identify probable causes.

Suggested statistical subjects to discuss include:

Discrete and continuous variables	Rounding of data
Scientific notation	Significant figures and computations
Independent and dependent variables	Regression and correlation
Graphs and charts	Frequency distribution
Mean, median, mode and other measures of central tendency	Standard deviation and measures of dispersion

EVALUATION

Written examination questions covering the material presented and practical demonstrations of the test methods should be administered. Five objective type questions covering the scientific principle and five subjective type questions covering suggested test applications are recommended for each method presented. Questions should cover student grasp of error causes and significance to the test purpose. Questions should also cover student's grasp of quality control applications for each method.

SOURCES OF INFORMATION

HISTORICAL BACKGROUND OF QUALITY CONTROL

Texts:

A History of Business. 2 Vols. Mariam Beard. Ann Arbor University of Michigan Press, Ann Arbor Paperbacks.

A History of Technology. 5 Vols. (From Early Times through 19th Century.) Clarendon Press. (Oxford) In U.S.A., Oxford University Press, New York. The most extensive work in the English language.

A History of Technology and Invention: Progress Through the Ages. Maurice Duamas, Editor. Crown Publishers, New York. 1969. (Originally published in French in 1969.)

The Industrial Revolution, 1760-1830. Thomas South-Cliffe Ashton. New York, Galaxy Editions (Oxford University Press). 1962. Paperbound.

A Short History of Technology. T. K. Kerry and Trevor Williams. Oxford University Press, New York. 1961. Called "short" by comparison to the massive five volume A History of Technology, also published by Oxford. (See Above)

Audio Visual:

Man and Measures--Filmstrip Series. 35mm. Color. Filmstrip House, 432 Park Avenue, South, New York, New York 10016. (1957) Titles:

Early Counting	40 Frames
Early Measuring	45 Frames
Early Time Telling	45 Frames
Geometric Figures	45 Frames

Measurement: How and Why. Filmstrip with captions, color, 25 frames. Amber Book Company, 450 West 33rd Street, New York, New York 10001. Develops concepts of linear, liquid, and dry measure. 1964.

America Becomes an Industrial Nation. 16mm. Sound. B&W. 25 minutes. McGraw-Hill Textfilms, 330 West 42nd Street, New York, New York 10018. 1967. This film relates how industrialization helped bring great wealth, power, and a rising standard of living as well as serious social, economic and political problems.

America: On the Edge of Abundance. 16mm. Sound. B&W. 59 minutes. Indiana University Audio-Visual Center, Bloomington, Indiana 47401. The economic and social aspects of the American computer-oriented, automated society as viewed by British television. Discusses the problems of retraining and increased leisure resulting from the change to a manufacturing, rather than an agricultural, society.

Beginnings and Growth of Industrial America. 16mm. Sound. Color. 11 minutes. Coronet Films, 65 East South Water Street, Coronet Building, Chicago, Illinois 60601. This film shows the development of American manufacturing and explains the factors which contribute to industrial growth, inventions, investments and labor. 1960.

History of the Measure of Length. 35mm. B&W. 32 frames. Visual Education Consultants, 2066 Helena Street, Madison, Wisconsin 53701. History of measurement from the cubit to the meter. Shows the international meter standard and its application to industry and science. 1967.

ECONOMIC BASES OF QUALITY CONTROL

Texts:

American Systems of Manufacturers. Nathan Rosenberg. Aldine Atherton, Inc., 529 South Wabash Avenue, Chicago, Illinois 60605. 1969.

Applied Economics: Introductory Principles Applied to Everyday Problems. J. W. Kennedy, A. R. Olsen, and J. H. Dodd, 7th Edition. Southwestern Publishing Company, Cincinnati, Ohio. 1967.

Business Enterprise in the American Economy. 2nd Edition. L. De Rycke, A. H. Thompson. Webster Division, McGraw-Hill Book Company, St. Louis, Missouri. 1968.

Audio Visual:

Economic System. T. Robert Harris. Didactic Systems, Inc., Box 4, Cranford, New Jersey 07016.

Economic Growth. 16mm. Sound. B&W. 30 minutes. Indiana University Audio-Visual Center, Bloomington, Indiana 47401. What causes business and economic growth, and how it is measured. From the American Business System series.

Economics: Risk and Resource. 16mm. Sound. Color. 12 minutes. (Free Loan) National Canners Association, 1133-20th Street, N.W., Washington, D.C. 20036.

How it Evolved. 16mm. Sound. B&W. 30 minutes. Indiana University Audio-Visual Center. Evolution of American Business methods from colonial times to present-day corporate procedures. From the American Business Systems series.

AFFECTS/EFFECTS OF MASS PRODUCTION INFLUENCES

Texts:

A Conceptual Framework for the Management Science. Marvin E. Mundel. McGraw-Hill Book Company, New York, New York. 1967. Has extensive coverage of the concept of control in management.

Dynamics for Process and System Control. Yang Wen-Jei. Gordon and Breach Science Publishers, Inc., 440 Park Avenue South, New York, New York 10016. 1969.

Integrated Manufacturing Systems. R. L. Martino. Illustrated. McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036. 1972.

Management Control Models. Earl P. Strong and Robert D. Smith. New York. Holt, Rinehart and Winston. 1968.

Manufacturing Management and Control. Dean S. Ammer. Appleton-Century-Crofts, 440 Park Avenue South, New York, New York 10016. Illustrated. Paperbound. Text Edition.

Audio Visual:

American Industry - A Series. Each tape 30 minutes. University of Michigan Audiovisual Education Center, 416 Fourth Street, Ann Arbor, Michigan 48103. (1971) Titles are:

Automobiles
Cereal Grains
Furniture
Lake Shipping

Paper
Salt
Trucks

Foundations of Modern Mass Production. Harcourt, Brace and World, 757 Third Avenue, New York, New York 10017. From the American Civics series. 1967.

Introduction to Control. 16mm. Sound. Color. 20 minutes. International Film Bureau, 332 South Michigan Avenue, Chicago, Illinois 60604. Shows the application of electronic and mechanical controls to industry.

Quality Control. 16mm. Sound. B&W. 10 minutes. McGraw-Hill Textfilms. Effects of quality control on manufacturing cost and consequently on price of a product. From the Industrial Management series. 1951.

Quality Control. (Free Loan) 16mm. Sound. Color. 18 minutes. Caterpillar Tractor Company, Advertising Division, 100 North East Adams Street, Peoria, Illinois 61602. Precision tools, uniform inspection practices, and their effect on quality assurance.

SYSTEMS TECHNOLOGY AND QUALITY CONTROL

Texts:

The Application of Holography to the Visualization of Tire Vibrations. (Reprint) G. R. Potts. GCO, Inc., Plymouth, Michigan. Highly technical, engineering level.

Fundamentals of Rockwell Hardness Testing. Anthony De Bellis. Reprint from Metal Treating Magazine. Wilson Instrument Division, American Chain and Cable Company, New York. Free to teachers.

Gilmore Industries - Vibration Testing Literature. (Includes various engineering bulletins and a "vibration computer.") Gilmore Industries, Cincinnati, Ohio. Free to teachers.

Holography Used in Nondestructive Testing with Particular Emphasis on Pneumatic Tires. (Reprint) Gordon M. Brown. GCO, Inc., Plymouth, Michigan. Highly technical article, useful for teacher reference. Free to teachers.

Precision Measurement - Student's Text. Brown and Sharpe, North Kingstown, Rhode Island. For those "interested in learning basics of quality inspection..."

Precision Measurement - Instructor's Guide. (Keyed to Student Text.) Contains outline and tests. Each volume - \$5.50.

Reading A Micrometer - Programmed Learning Series in In-Shop Practices. Society of Manufacturing Engineers, Dearborn, Michigan. Programmed learning course. For engineers and students of engineering.

Audio Visual:

Short Time Intervals. 16mm. Sound. B&W. 21 minutes. (Free Loan) Modern Talking Picture Services, 1212 Avenue of the Americas, New York, New York 10036. This film is a study of extension of senses to within very short time intervals. Timing devices shown include moving cameras, pen recorders and the oscilloscope, with an explanation of its use in these measurements.

Reliability Series. United States National Audio-Visual Center.
All films are 16mm. Sound. Color. They may be purchased separately.
 Made for the United States Navy. 1961. Titles are:

Reliability -- Fundamental Concepts -- Part I	30 Minutes
Reliability -- Fundamental Concepts -- Part II	27 Minutes
Reliability: Statistical Concepts	25 Minutes
Reliability Engineering: Reliability Testing	30 Minutes
Reliability -- Reliability Testing	25 Minutes
Reliability -- Specifications and Reliability Assurance	25 Minutes
Reliability -- Elements of Reliability Prediction	30 Minutes
Reliability -- Part and Parcel	28 Minutes

Right - The First Time. 16mm. Sound. Color. 10 minutes. (Free Loan) Lockheed-Georgia Company, Motion Picture Film Library, Zone 30, B-2 Building, Marietta, Georgia 30060. Details of the Lockheed Zero Defects Program, from early study through implementation.

The Metric System. 16mm. Sound. Color. 13 minutes. NBC Educational Enterprises, 30 Rockefeller Plaza, New York, New York 10020. Animated film, from the Mathematical Relationships Series.

Understanding the Metric System. 16mm. Sound. Color. 8 minutes. The Pennsylvania State University, Audio-Visual Services, 7 Willard Building, University Park, Pennsylvania 16802. Uses the Olympic Games as a means of introducing the metric system; relates metric system to our decimal system of currency. 1972.

STATISTICS IN QUALITY CONTROL

Texts:

Engineering Statistics and Quality Control. I. W. Burr. McGraw-Hill Book Company, New York. 1953.

Introduction to Probability and Statistics. Bernard W. Lindgren and G. W. McElrath. MacMillan Company, Sub. of Crowell, Collier and MacMillan, Inc., Riverside, New Jersey 08075. 1969.

Quality Control and Industrial Statistics. A. J. Duncan. Richard D. Irwin, Inc., 1818 Ridge Road, Homewood, Illinois 60430. 1965. Text Edition.

Statistics: An Introduction. A. D. Rickmers and H. N. Took. McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036. 1967.

Audio Visual:

Applications of Random Sampling. Transparencies, set of 18. Includes applications to Quality Control. Includes random-number dice. Lansford Publishing Company, P.O. Box 8711, San Jose, California 95155.

Introduction to Numerical and Graphical Statistics. 35mm. Color. 46 frames. Colonial Films, 752 Spring Street, N.W., Atlanta, Georgia 30308. Organizing data, ranking percentiles, central tendency and probability. From the Elementary Math Series No. 5. 1966.

Introduction to Statistical Calculations: A Series. Educational Record Sales, 157 Chambers Street, New York, New York 10007. Making of graphs, interpreting graphs, basic calculations. Titles are:

- Calculation of Standard Deviation From...
- Calculation of Standard Deviation From 1
- Calculation of the Arithmetic Mean From A
- Calculation of the Arithmetic Mean From A1
- Calculation of the Arithmetic Mean From A2
- Characteristics of the Normal Curve
- Correlation--Calculating the Degree of Regression
- Standard Deviation, Best Fitting
- Use of the Normal Curve

Predicting at Random. 16mm. Color. Sound. 43 minutes. Modern Learning Aids, Inc. A leading statistician poses a practical problem and shows how to solve it.

Random Events. 16mm. B&W. Sound. 31 minutes. Modern Talking Picture Service, 1212 Avenue of the Americas, New York, New York 10036. (Free Loan) This film shows how the overall effect of large numbers of random (unpredictable) events can be very predictable. Several unusual games are played to bring the statistical nature of this predictability. 1962.

Statistics. 35mm. Color. 44 frames. Eye Gate House, Inc., 146-01 Archer Avenue, Jamaica, New York 11435. Introduces histograms, central tendency and cumulative frequency. 1968.

Statistical Quality Control - Acceptance Sampling. 16mm. Sound. B&W. 18 minutes. United States National Audio-Visual Center, Washington, D.C. 20409. How government inspectors use acceptance sampling techniques. 1951.

Statistics - Mean, Median, Mode. 35mm. Color. 39 frames.
McGraw-Hill Textfilms, 330 West 42nd Street, New York, New York
10036.

Using Statistics - Making the Best Decision. 35mm. Color. 37
frames. McGraw-Hill Textfilms.

Statistical Quality Control - Process Control. 16mm. Sound.
B&W. 12 minutes. United States National Audio-Visual Center.
Uses of process control to obtain a better product a cheaper price
for the United States Government. 1951.

AN OVERVIEW OF INSPECTION AND MEASUREMENT

Texts:

Bausch and Lomb Science Teaching Aids, and Bausch and Lomb Edu-
cational Films. Bausch and Lomb, Rochester, New York. Both free
to teachers.

Brown and Sharpe Reference Data for Teachers. Brown and Sharpe,
North Kingstown, Rhode Island. Various pamphlets and charts on
the use of precision measuring instruments and equipment, all free
to teachers. Write: Brown and Sharpe Manufacturing Company,
Industrial Products Division, Precision Park, North Kingstown,
Rhode Island 02852. Attention: Advertising Manager.

Machined Parts Inspection - A Programmed Instruction (Self-Study)
Course for Machine Parts Inspectors. General Dynamics Convair
Division, San Diego, California 92138. 1974.

Metric Units of Measure. Booklet, 11 pages. Metric Association,
Inc., 2004 Ash Street, Waukegan, Illinois 60085. Information
booklet for classroom teachers. 1968. \$1.00 for ten copies.

Sampling Inspection Tables, Single and Double Sampling. 2nd
Edition. John Wiley and Sons. New York. 1959.

Audio Visual:

How to Use Measuring Tools. 16mm. Sound. Color. 20 minutes.
(Free Loan) Stanley Tools, 600 Myrtle Street, New Britain,
Connecticut 06050. Demonstrates use of the folding rule, steel
tape, and other basic measuring tools.

Measurement. 16mm. Sound. B&W. 20 minutes. Time-Life Broad-
cast, Inc., Time and Life Building, Rockefeller Center, New York,
New York 10020. Shows need for standard measurement units, and
the fundamentals of measuring.

Manufacturing Control. Sound filmstrip-audio tape. Color. International Business Machines, Armonk, New York 10504. Describes some of the many facets of manufacturing planning and control.

Measuring and Layout Tools. 16mm. Sound. Color. 13 minutes. Sterling Educational Films, P.O. Box 8497, Universal City, Los Angeles, California 91608. This film depicts measuring tools for wood work--rules and tapes, squares, try squares, gauges, compasses, dividers and trammel points. 1967.

Probability. 16mm. Color. Sound. 12 minutes. McGraw-Hill Textfilms. Basic concept, formulae for calculating the measure of probability of an event. Formulae applied to a few simple cases. 1966.

Probability. 16mm. Sound. B&W. 13 minutes. NBC Educational Enterprises, 30 Rockefeller Plaza, New York, New York 10020. Explores the combination of probability and chance over a large number of occasions. From the Mathematical Relationships series. 1970.

Probability. 16mm. Sound. Color. 9 minutes. BFA Educational Media, 2211 Michigan Avenue, Santa Monica, California 90404. Uses cards, discs, etc., to show fundamentals of probability, and the writing of probability statements in the form of equations. 1969.

Understanding the Physical World Through Measurement. 16mm. Sound. Color. 33 minutes. United States National Audio-Visual Center, Washington, D.C. 20409. History of man's struggle to harness energy and demonstrations of transformations between types of energy. 1957.

Why Measure? 16mm. Sound. Color. 6 minutes. The Pennsylvania State University, Audio-Visual Center. Importance of measurement in everyday life, as well as in the laboratory. Need for and development of standards for measurement; their relationship to science and technology. 1972.

THE QUALITY CONTROL CAREER FIELD

Texts:

Human Factors in Quality Assurance. Douglas H. Harris and Frederick B. Chaney. Wiley, John and Sons, 605 Third Avenue, New York, New York 10016. 1969.

Military Handbooks:

MIL-HDBK-50, Evaluations of Contractors Quality Programs,
(MIL-Q-9858). United States Government Printing Office,
Washington, D.C. 20202.

MIL-HDBK-51, Evaluations of Contractors Inspection Systems.
(MIL-I-45208). United States Government Printing Office,
Washington, D.C. 20202.

MIL-HDBK-52, Evaluation of Contractors Calibration Systems.
(MIL-C-45662). United States Government Printing Office,
Washington, D.C. 20202.

Procurement Quality Control, Handbook of Recommended Practice.
American Society of Quality Control, 161 West Wisconsin Avenue,
Milwaukee, Wisconsin 53320.

Quality Control for the Food Industry. Amihud Kramer and Bernard A.
Twigg. Volume 1: Fundamentals. 3rd Edition. Illustrated. AVI
Publishing Company, Inc., Box 831, Westport, Connecticut 06880.
1970.

Quality Control for the Manager. 2nd Edition. A. F. Cowan.
Pergamon Press, Inc., Sales Department, Maxwell House, Fairview
Park, Elmsford, New York 10523.

Quality Control for Managers and Engineers. Elwood G. Kirkpatrick.
Wiley. John and Sons, 604 Third Avenue, New York, New York 10016.

Quality Control and Reliability. Revised Edition. 6th Edition.
Industrial, 200 Madison Avenue, New York, New York 10016. 1972.

Audio Visual:

Background for Leadership. 16mm. Sound. Color. 30 minutes.
Dana Productions, 425 East 51st Street, New York, New York 10022.
This film illustrates the major manufacturing processes required
to produce piston rings, chrome plating, sleeve casings, speed
controls and valve seals. Views the research and testing required
to produce these automotive products.

Day With The Upjohn Company. 16mm. Sound. Color. 29 minutes.
Distributor: Upjohn Company, 7000 Portage Road, Kalamazoo,
Missouri 49001. This film traces beginning and development of
Upjohn Company and describes company's programs and research and
clinical testing, manufacture and packaging of products, filtering
and extracting processes, testing and bottling procedure and
assembly-line operations. 1965.

Inspection of Minor Assemblies. 16mm. Sound. B&W. 16 minutes. United States National Audio-Visual Center, Washington, D.C. 20409. How to inspect a minor assembly in detail, read rivet specifications and inspect rivets.

Inspection of Sheet Metal Parts. 16mm. Sound. B&W. 20 minutes. United States National Audio-Visual Center. Planning and implementing routine inspection procedures. Detailed and spot-check inspections.

Quality Control. 35mm. Sound (disc). Color. 54 frames. Society for Visual Education, Inc., Division of the Singer Company, 1345 Diversey Parkway, Chicago, Illinois 60614. What quality control personnel do, how quality standards are set for manufacturing. From the series titled, Industry in 20th Century America - Group I. 1967.

Quality Control. 16mm. Sound. Color. 25 minutes. United States National Audio-Visual Center, Washington, D.C. 20409. Air Force quality control program and responsibilities. 1955.

Quality Control - A Management Tool. 16mm. Sound. Color. 21 minutes. United States National Audio-Visual Center. Quality control in government depots, air commands, and in industrial plants doing work for the United States government, particularly in the aircraft and missile areas. 1959.

EDUCATION, TRAINING AND PROFESSIONAL DEVELOPMENT IN QUALITY CONTROL

Texts:

A Study Leading to the Development of a Teaching-Learning Curriculum Exemplar for Quality Control Education in the High School. Paul E. Gelles. Dissertation: United States International University, San Diego, California. 1972.

Engineering Careers Edition, Index of Employment Opportunities. Resource Publications, Inc., Information Park, Box 2236, Princeton, New Jersey 08540. (609) 924-9427. A geographical arrangement of company recruiting materials. Each company gives list of kinds of careers available, etc. (Regional Breakdown). Subject "occupational index" at end of each section. Includes Quality Control opportunities, but no "occupational index" heading as such.

Quality Costs - What and How. Workbook. American Society for Quality Control, 161 West Wisconsin Avenue, Milwaukee, Wisconsin 53203. 1967.

Sources of Career Information in Scientific Fields, 1971-72.
Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W.,
Washington, D.C. 20009. Free to teachers.

Quality Education Opportunities in San Diego. Paul E. Gelles.
Paper presented at annual San Diego ASQC Seminar. San Diego,
California. 1974.

The Americans: The Democratic Experience. Daniel J. Boostin.
Random House, New York. 1973. There is an excellent nontechnical
article on pp. 193-200, comprising a brief history of statistical
quality control. Author is an official of the Smithsonian
Institute.

Audio Visual:

Accent on Excellence. (Free Loan) 16mm. Sound. Color. 14
minutes. TRW Systems Group, Attention: Motion Pictures, Building
65, Room 1521, One Space Park, Redondo Beach, California 90278.
Shows the scope, function, and diversity of Product Assurance
Program at TRW Statems Group. 1969.

Everything Is Beautiful. (Free Loan) 16mm. Sound. Color. 10
minutes. Modern Talking Picture Service, 2323 New Hyde Park Road,
New Hyde Park, New York 11040. Shows how the world would look
without color; depicts manufacture of paint colors, with emphasis
on quality control.

For Eyes to See. (Free Loan) 16mm. Sound. Color. 28 minutes.
Bausch and Lomb, Inc., Film Distribution Service, 635 St. Paul
Street, Rochester, New York 14602. Modern application of scien-
tific instruments for education, research, and quality control.

High School Course Selection. 35mm. Color. Part I: 115 frames;
Part II: 118 frames. Guidance Associates. From the "Secondary
School Orientation" series.

Industrial Research--Key to Jobs and Progress. (Free Loan) 16mm.
Sound. B&W. 14 minutes. National Association of Manufacturers,
277 Park Avenue, New York, New York 10017. Roles of the engineer
and the scientists in the development of new products.

Technicians of Tomorrow. 16mm. Sound. Color. 20 minutes.
United States Office of Education, 400 Maryland Avenue, S.W.,
Washington, D.C. 20202. 1966.

BLUEPRINT READING

Texts:

Blueprint Reading - Job Entry Training Manual. National Machine Tool Builders Association, Washington, D.C. 1970.

How to Read Shop Drawings, with Special Reference to Welding and Welding Symbols. Lincoln Electric Company, Cleveland, Ohio. 1961.

Blueprint Reading. 2 Vols. Westinghouse Learning Corporation, New York. 1970. Programmed Text. Very simply presented.

How to Read Electrical Blueprints. 2nd Edition. Reverend Charles H. Dunlap, and C. S. Jones. American Technical Society, Chicago. 1954.

Audio Visual:

According to Plan: Introduction to Engineering Drawing. 16mm. Sound. B&W. 9 minutes. McGraw-Hill Textfilms, 330 West 42nd Street, New York, New York 10036. Shows how engineering drawings is the common language that unites the many people needed in a modern production effort. 1947.

Drafting - An Introduction. 35mm. Color. Doubleday Multimedia, 1370 Reynolds Avenue, Santa Ana, California 92705. Shows application of drafting terms to other skill areas; shows basic tools and techniques. 1970.

Drawings and the Shop. 16mm. Sound. B&W. 15 minutes. McGraw-Hill Textfilms. How drawings are related to the shop, and the reasons for certain requirements.

Shop Procedures. 16mm. Sound. B&W. 17 minutes. McGraw-Hill Textfilms. Use of finished drawings as detailed instructions in each phase of the manufacturing process, making and use of blueprints in the patternmaking shop, foundry, and other shops. 1947.

Blueprint Reading - A Series. Tehnifax Corporation, 195 Appleton Street, Holyoke, Massachusetts 01040. Uses the project approach to teach basic skills in reading and interpreting technical drawings.

Drafting Techniques - A Series. Photo and Sound Company, 5515 Sunset Boulevard, Los Angeles, California 90028. A set of 40 transparencies with varying numbers of overlays. Many are concerned with the various aspects of dimensioning.

Machine Trades Blueprint Reading. 5th Edition. R. W. Ihne, W. E. Streeter. American Technical Society, Chicago. 1966.

STATISTICS IN QUALITY CONTROL

Texts:

Quality Control and Reliability. N. L. Enrich. Textile Book Service, Box 907, Plainfield, New Jersey 07060. 1969.

Quality Control and Reliability Management. Training Manual. American Society for Quality Control, 161 West Wisconsin Avenue, Milwaukee, Wisconsin 53203. 1969.

Quality Control by Statistical Methods. L. A. Knowler, et al., McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036. 1969. Text Edition.

Quality Control Handbook. Joseph M. Juran. McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036. Illustrated.

Quality Control: Theory and Application. Bertrand Hanse. Illustrated. Prentice Hall, Inc., Englewood Cliffs, New Jersey 07632. 1963.

Quality Control Workbook. David J. Desmond. Cahners Publishing Company, Inc., 89 Franklin Street, Boston, Massachusetts 02116. 1972.

Reliability Concepts in Engineering Manufacture. Author: R. H. Brook. Publisher: John Wiley and Sons, Inc., 605 Third Avenue, New York, New York 10016. 1972.

Reliability Handbook. Authors: B. A. Kozlon and I. E. Ushakov. (International Series in Decision Processes) Publishers: Holt, Rinehart and Winston, Inc., 383 Madison Avenue, New York, New York 10017. 1970. Text Edition.

Audio Visual:

Principal Dimensions, Reference Surfaces, and Tolerances. 16mm. Sound. B&W. 12 minutes. United States National Audio-Visual Center, Washington, D.C. 20409. Relationship of the blueprint to the rough and finished casting; use of reference surfaces; interpretation of tolerances. 1944.

Selection of Dimensions. 16mm. Sound. B&W. 18 minutes. McGraw-Hill Textfilms. Principles covering choice of dimensions, functional character of objects and manufacturing method used. 1947.

MECHANICAL MEASUREMENT

Texts:

Machine Shop Measurement. Delmar Publishing Company, Albany, New York. 1970.

Metrics for Mechanics (Self-Study Course). Volkswagen of America, Inc., Englewood Cliffs, New Jersey 07632.

Reliability: Management, Methods, and Mathematics. Authors: David K. Lloyd and M. Lipow. Publisher: Prentice-Hall, Englewood Cliffs, New Jersey 07632. 1962. Illustrated.

Reliability Principles and Practices. Author: S. R. Calabro. Publisher: McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036. 1962.

Reliability Theory and Practice. Author: Igor Bazovsky. Publisher: Prentice Hall, Englewood Cliffs, New Jersey 07632.

Audio Visual:

General Mathematics - Filmstrip Series. McGraw-Hill, 330 West 42nd Street, New York, New York 10036. All filmstrips are 35mm, color, with captions. 1971. Titles are:

Measurement With Dials and Calipers	47 Frames
Metric System, The	44 Frames
Saying it in Algebra	42 Frames
Scale Drawing	39 Frames
Trigonometry	
Using Approximation	47 Frames

Linear Measurement. 35mm. Sound (audiotaped). B&W. 42 frames. Eye Gate House, Inc., 146-01 Archer Avenue, Jamaica, New York 11435. From the Basic Laboratory Techniques series.

Measurement--Developing Units for Measurement. 35mm. Color. ABC-TV, 1330 Avenue of the Americas, New York, New York 10019. Stresses the need for standard units, shows measurement as a concept of comparison, as in inspection.

Measurement--Precision. 35mm. Filmstrip with captions. Color. 40 frames. Popular Science Publishing Company, 355 Lexington Avenue, New York, New York 10017. Presents the concept of measurement as approximation, and shows tolerances and intervals within which true measurement can fall. From the Elementary Mathematics series. 1967.

Taking Inside Measurements. 16mm. Sound. Color. 9 minutes. Carousel Films, 1501 Broadway, New York, New York 10036. Presents basic information about the techniques of taking inside measurements. 1969.

Tools and Rules for Precision Measuring. 16mm. (Free Loan) L. S. Starrett Company, Athol, Massachusetts 01331. (See booklet above, same title.) Highlights in the history of precision measuring. Explains how precision tools control quality in mass production.

Precision Measuring - A Series. 16mm. Sound. Color. BFA Educational Media, Inc., 2211 Michigan Avenue, Santa Monica, California 90404. 1973. Titles and running times are:

Precision Measuring -- Combination Square	15 Minutes
Precision Measuring -- Depth Gage and Inside Micrometer	15 Minutes
Precision Measuring -- Micrometer	14 Minutes
Precision Measuring -- Steel Square, Part I	8 Minutes
Precision Measuring -- Steel Square, Part II	8 Minutes
Precision Measuring -- Vernier Calipers	15 Minutes

Verniers. 16mm. Sound. B&W. United States National Audio-Visual Center. Animated cartoon illustrates the basic principles of the vernier scale and shows its application to precision measurement. 1941.

ELECTRICAL MEASUREMENT

Texts:

Basic Electrical Measurements. 2nd Edition. M. B. Stout. Prentice-Hall. 1960. Uses algebraic approach to solution of problems.

Basic Electricity and an Introduction to Electronics. (2nd Edition) Howard W. Sams Editorial Staff. Howard W. Sams, Inc. Covers all the fundamentals in simple easy to understand text. Practical projects and numerous illustrations. Ideal for home study or classroom use. 192 pages. 8-1/2 x 11 softbound.

Basic Electronic Test Instruments: Their Principles and Operations. Reverend Edward Rufus P. Turner. Holt, Rinehart and Winston, 383 Madison Avenue, New York, New York 10017. 1963.

Basic Electronic Test Procedures. R. P. Turner. Holt, Rinehart and Winston, 383 Madison Avenue, New York, New York 10017. 1959.

Handbook of Electronic Instruments and Measurement Techniques.
H. E. Thomas and C. A. Clarke. Prentice-Hall. 1967.

Handbook of Materials and Processes for Electronics. Charles A. Harper. McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036. 1969.

Practical Oscilloscope Handbook. Rufus P. Turner. John F. Rider Company, New York. 1964. 2 volumes in one.

Audio Visual:

Basic Electricity - A Series. United States National Audio-Visual Center, Washington, D.C. 20409. All films are 16mm, sound, B&W. Titles and running times are:

<u>Basic D.C. Meter Movement</u>	3 Minutes
<u>Current Flow, What It Is</u>	4 Minutes
<u>Electromagnets</u>	3 Minutes
<u>Electron Theory, The</u>	5 Minutes
<u>How Magnets Produce Electricity</u>	4 Minutes

Electronics--Meters--A Series. 8mm. Film Loop Set. All loops are 8mm. Silent, Color. 4 minutes. Ealing Corporation, 2225 Massachusetts Avenue, Cambridge, Massachusetts 01240. Titles are:

Ammeters and Shunts	Moving Coil in A-C
Current Measurent	Measurement
Meter Movement - Electrodynamometer	Ohmmeters
Meter Movement - Iron Vane	Power Measurement
Meter Movement - Moving Coil	Voltage Measurement
Voltmeters and Multipliers	

Electricity--Measurement. 16mm. Sound. Color. 12 minutes. Indiana University Audio-Visual Center, Bloomington, Indiana 47401. Measurement of electrical pressure (EMF) and current flow. 1962.

Measuring Changing Voltages. 8mm. Cartridges. MacMillan Company, 866 Third Avenue, New York, New York 10011.

Measurement of Resistance. 35mm. Filmstrip with captions. Color. 43 frames. Popular Science Publishing Company, 355 Lexington Avenue, New York, New York 10017. Ohms Law, units of electrical measurement are reviewed, and various direct and indirect measurements are shown. From the High School Physical Science series. 1967.

Principles of Electrical Measurements. 16mm. Sound. B&W. 22 minutes. DeVry Technical Institute, 4141 Belmont Avenue, Chicago, Illinois 60641. How various electrical instruments are built, and their operation. 1959.

Principles of Electrostatics. 16mm. Sound. B&W. 22 minutes. DeVry Technical Institute. Polarity, electrical conductors and insulators; induction; distribution of charges. 1951.

Wire Sizes and Voltage Drop. 16mm. Sound. B&W. 13 minutes. United States National Audio-Visual Center. 1945.

CHEMICAL MEASUREMENT

Texts:

Chemical Equilibrium and Solutions: A Programmed Introduction. James E. Banks. McGraw-Hill, New York. 1967.

The Encyclopedia of Chemistry. George L. Clark. Editor in Chief, Reinhold Publishing Company, New York. \$25.00.

Introduction to Chemistry. Arthur L. Williams and others. Addison-Wesley Publishing Company. 1968.

Introduction to Laboratory Chemistry. 6th Edition. Leslie E. Arnow and Marie E. C. Logan. Mosby Publishers, Philadelphia, Pennsylvania. 1961.

pH Measurement and Titration. G. Mattock. MacMillan. New York. 1961. From the series, Physical Processes in the Chemical Industry.

United States Atomic Energy Commission Information Booklets. Order from USAEC-Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830. Prices are as follows:

1-4 Booklets	25¢ each
5-99 Booklets	20¢ each
100 or more Booklets	15¢ each

Audio Visual:

Acids, Bases and Salts. 16mm. Sound. Color. 21 minutes. Historical background, household and industrial uses, and commercial production. 1959. Coronet Instructional Films, 65 East South Water Street, Coronet Building, Chicago, Illinois 60601.

Basic Principles of the Analytical Balance. 35mm. Sound. B&W. 100 frames. United States National Audio-Visual Center, Washington, D.C. 20409. How to find zero point, sensitivity; how to weight out material.

Chemstudy - Part I - A Series. Chemstudy - Part II - A Series. Minnesota Mining and Manufacturing Company, (3M Library, 2501 Hudson Road, St. Paul, Minnesota 55119). 1966. This set includes approximately 200 transparencies which cover the fundamentals of chemical concepts and techniques. Included are more than 25 experiments.

Chemistry - A Series. Visual Sciences, Box 599, Suffern, New York 10901.

Experiments in Chemistry - A Series. 35mm. Filmstrips with captions. Color. Encyclopedia Britannica Educational Corporation, 425 North Michigan Avenue, Chicago, Illinois 60611. 1964. Titles:

Acids and Bases	30 Frames
Boyle's Law	30 Frames
Charles' Law	30 Frames
Chemical Reactions	30 Frames
Chemistry of Boron and Aluminum	31 Frames
Chemistry of Columns I and II	30 Frames
Chemistry of Iron	30 Frames
Chemistry of Sulfur	30 Frames
Chemistry of Sulfuric Acid	30 Frames
Chemistry of the Halogens	30 Frames
Crystallization	30 Frames
Determination of a Formula	30 Frames
Electrochemistry	30 Frames
Energy of Reactions	30 Frames
Equilibrium	30 Frames
Equivalent Weight	30 Frames
Experiments with Subatomic Particles	30 Frames
Hdrolysis	30 Frames
Introduction to the Chemistry Laboratory	
Part I	40 Frames
Introduction to the Chemistry Laboratory	
Part II	42 Frames
Ionization	30 Frames
Measurement in Chemistry	30 Frames
Molecular Volume of Gas	30 Frames
Oxidation/Reduction Reactions	30 Frames
Oxidation/Reduction Titration	30 Frames
PH	30 Frames
Qualitative Analysis	30 Frames
Reaction Rates	30 Frames
Size of Molecules, The	30 Frames
Titration	30 Frames

Industrial Uses of Radio-Isotopes. 16mm. Sound. Color. 10 minutes. United Kingdom Atomic Energy Authority, 11 Charles Street, London, S.W. 1, England. Shows some of the industrial applications of atomic energy, particularly in testing. 1960.

Using the Air Damped Balance. 16mm. Sound. Color. 6 minutes. Encyclopedia Britannica Educational Corporation, 425 North Michigan Avenue, Chicago, Illinois 60611.